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THE TRACTRIGRAPH, AN IMPROVED FORM OF HATCHET PLANIMETER.

By A. L. Menzin.*

The methods recommended for using the hatchet planimeter† involve an error, whose magnitude is so uncertain that the usefulness of the instrument is greatly limited. These methods are based on the elimination of an area whose value depends upon the path of the hatchet blade. In a paper published in 1899,‡ Dr. D. N. Lehmer showed by an original development of the theory, that the elimination of this area is non-essential; for, by arbitrarily choosing certain conditions, this area could be satisfactorily approximated. The "Tractrigraph," a development of the hatchet planimeter permitting much greater accuracy of measurement, was recently designed to test the practicability of this method. The results obtained were encouraging. Before attempting to describe the instrument, it is deemed advisable to give a short discussion of the theory which governs its use.

Dr. Lehmer showed that, when a tangent of constant length measured from the points of tangency moves along a curve, the area swept out is equal to $\frac{1}{2} L^2\theta$, where L is the length of the tangent line, and θ is the angle between its initial and final positions. Thus, in Fig. 1, when the tangent L moves along the curve A B, the area swept out is A B D C. To prove that this area equals $\frac{1}{2} L^2\theta$, A B may be divided into n parts, and the tangent line moved along the chords joining the points of division. The area swept out is seen to consist of sectors of a circle of radius L. If it were possible to slide each of these on its neighbor until their arcs joined, the result would be a single sector of angle θ, and therefore of area equal to $\frac{1}{2} L^2\theta$. Since this relation is independent of the actual number of chords, it must still hold when n is increased indefinitely; that is, when the broken line and A B become identical.

Such a curve as A B, whose tangents are cut off at a constant distance from the points of tangency by another curve C D, has been called the "L-tractrix" of the base curve C D.

The sign of the area must be considered, and will be positive or negative according as the tangent line has rotated in a counter-clockwise or clockwise direction about points on the tractrix; for the area swept out is the result of elements of rotation about these points as centers.

We shall now follow the motion of the tangent line about a tractrix m n p, Fig. 2, whose base curve happens to be closed. Starting at position 1 at the point p, the tangent moves in a counter-clockwise direction to position 2. At a it encounters a point of inflection and moves clockwise to position 3. Its direction of motion is again reversed, and it moves counter-clockwise to position 4. The point o, at the extremity of the tangent, has now gone completely around the contour A. The areas swept out are the simple-hatched areas A_1 and A_2 positive and B negative, other areas being cancelled by both positive and negative motions (shown in Fig. 2 by double hatching). The angle θ is positive, and therefore by the preceding theorem

$$A_1 + A_2 - B = \tfrac{1}{2} L^2\theta.$$

Adding and subtracting V (the area of the unshaded wedge) to the left-hand side, the equation becomes

$$A_1 + A_2 + V - (V + B) = \tfrac{1}{2} L^2\theta.$$

Here $A_1 + A_2 + V$ may be replaced by A, and V + B by its two parts (1) the triangle m o p and (2) the area m n p. By trigonometry the area of the triangle equals $\frac{1}{2} L^2 \sin\theta$. Designating the area m n p by T, it follows that

$$A - \tfrac{1}{2} L^2 \sin\theta - T = \tfrac{1}{2} L^2\theta$$

or

$$A = \tfrac{1}{2} L^2 (\theta + \sin\theta) + T \qquad (1)$$

which is the fundamental equation connecting the area of a closed curve with that cut off when the extremities of the L-tractrix are joined by a straight line.

The sign of T is not always positive, as in the preceding case; in fact, T may consist of both positive and negative parts, or may be entirely negative, depending on the relative position of the initial tangent to the base curve. The usual conventions for determining the signs of areas and angles are applicable to this theorem, which is perfectly general. Those desiring an analytical proof are referred to the original paper.

Equation (1) requires some modification to make it practical for planimetric work. Dr. Lehmer therefore replaces $\frac{1}{2} L^2 (\theta + \sin\theta)$ by L b, which is a very close approximation, b being the distance m p between extremities of the tractrix; and notes that under certain conditions the area m n p = T can be made to resemble a triangle very closely, and may therefore be replaced by $\frac{1}{2}$ b h, where b is the base and h the altitude of the equivalent triangle. With these modifications, equation (1) becomes

$$A = L\,b + \tfrac{1}{2}\,b\,h = b\,(L + \tfrac{1}{2}\,h) \qquad (2)$$

For the condition that T and A are of opposite signs, the formula is

$$A = b\,(L - \tfrac{1}{2}\,h) \qquad (3)$$

To make these formulas available for computing areas, some means must be provided for obtaining an L-tractrix. The Tractrigraph, as its name indicates, was designed for this particular purpose. When the tracing point is dragged along a curve, the pencil simultaneously draws the L-tractrix; for instance, Schiele's "anti-friction" curve can be obtained by using a straight line for a base curve.

The instrument is shown in Fig. 3, a reproduction of a photograph. Its construction is simple and may be explained as follows. A pencil-holder fits rather loosely in a hole drilled through the middle of a frame mounted on wheels. One end of an arm is rigidly attached to the frame by means of a thumb screw, the other end has a short slot to receive a knurled tracer. Two headless set-screws bear against the tracer and allow it to be shifted so that its point lies in a line through the pencil at right angles to the axis of the wheels. The pencil-holder is a cylinder drilled at one end to receive a lead, and capped at the other by a finished head, the weight of which maintains a constant pressure on the lead and takes up its wear. A set-screw bears loosely against a partially flattened side of the pencil-holder and prevents it from falling out when the instrument is handled. The arm is readily detached and can be lengthened by inserting the extension seen in the foreground in Fig. 3. In this way the arm lengths remain constant, and need be determined only once for any particular instrument. The arms of the one shown are respectively 8 and 15 ins.

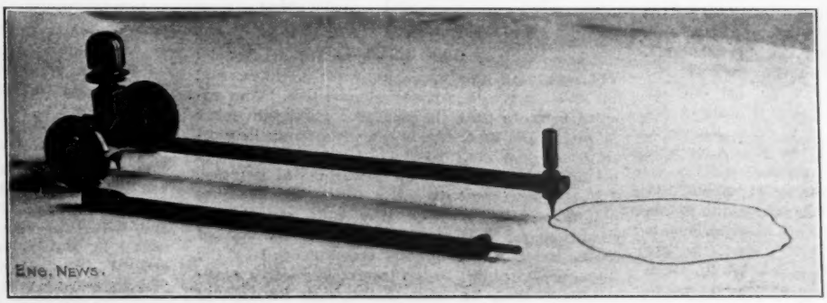


FIG. 3. VIEW OF TRACTRIGRAPH, AN IMPROVED FORM OF HATCHET PLANIMETER.

To adjust the tracer, the tracing point and pencil are placed on a straight line. The tracing point is moved along the line, and if the pencil shows no tendency to run off, the instrument is in adjustment. Otherwise the tracer must be shifted until this condition is obtained. Once made, the adjustment is practically permanent.

The accuracy of the instrument is best shown by the manner in which it is tested. An irregular French curve is thumb-tacked over a large sheet of paper on a drawing board. Using the edge of the curve as a guide, the tracing point is moved completely around it and back again. Perfect adjustment requires that the original tractrix shall be retraced on the backward motion, which is invariably done even though the paper be of very poor quality.

To compute the area of a closed curve, the

*946 Poplar St., Oakland, Cal.

†Ency. Britannica, Vol. xxx., p. 580; Engineering, Vol. 57, pp. 687, 813; Vol. 62, pp. 205, 255; Phil. Mag., May, 1894.

‡Annals of Mathematics, October, 1899.

tracing point of the Tractrigraph is set over a pencil mark on the contour; and the instrument set relatively to the curve as shown in the photograph. This will give the condition required for formula (3). For formula (2), the position of the arm is similar to 1 in Fig 2. Either may be used, but the first is preferable principally because T will be more pointed at its apex, and therefore more like a triangle.

With the instrument in suitable position the contour is traced once, the extremities of the tractrix being conveniently marked by giving the

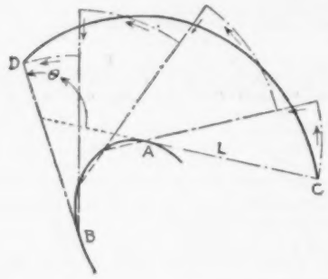


Fig. 1. Relation of Tractrix and Base Curve.

pencil a slight shove at right angles to the arm just before and after the tracing. The distance between extremities, which is b in the formula, is measured with dividers and scale to hundredths of an inch.

An effective method for obtaining the approximate altitude of the triangle equivalent to T, is this: Close the tractrix (Fig. 4) by a line A B. By eye bisect A B by a line C D drawn through the apex of tractrix. Rotate a transparent straight-edge (the writer uses a piece of window glass) about A as a center until the area bounded by A E, E D, and the straight-edge is judged equal to that part of T on the left of C D. Mark the intersection P of C D and the straight-edge. Treat the area on the right of C D in a similar way, the intersection being at Q. Set one leg of a pair of dividers on the line C D midway between P and Q, and adjust the other leg until, when swung, it just touches the line A B; h is then equal to the set of the dividers.

The method is justified as follows: Since that part of T on the left of C D is equivalent to the triangle A E P, it must equal $\frac{1}{4} b h_1$, where h_1 is the altitude for the base $\frac{1}{2}b$. Similarly the area of T on the right of C D equals $\frac{1}{4} b h_2$, since the bases of both triangles are arbitrarily made equal. Hence the total area of T equals

$$\frac{b}{2}\frac{h_1}{2} + \frac{b}{2}\frac{h_2}{2} = \frac{b}{2}\left(\frac{h_1 + h_2}{2}\right) = \frac{b}{2} h$$

Since h is the average of h_1 and h_2, the method of obtaining it with the dividers is obvious.

The instrumental length L being a constant for the instrument, and b and h determined from the tractrix, the formula may be used to compute the area.

The sides of a tractrix of almost any irregular closed curve can be made to deviate very little from two straight lines by using an arm not shorter than once or twice the longest line across the area to be measured. For such a relation the resemblance of T to a triangle is very marked, and the approximation offers no difficulty. Experiments indicate that the 8-in. arm can be used on areas up to 12 or 15 sq. ins., and the 15-in. arm on areas up to 100 sq. ins.

The error involved in replacing $\frac{1}{2} L^2 (\theta + \sin \theta)$ by L b may be read off from a table in which the errors are tabulated in terms of b to tenths of an inch for standard arms of 8 and 15 ins. When the 8-in. arm is used on areas under 10 sq. ins., and the 15-in. arm on areas under 50 sq. ins., the error will not ordinarily exceed one-half of 1%, and may be safely neglected.

Various tests were made to determine the efficiency of the instrument and method. The scheme indicated in Fig. 5 is perhaps best adapted to show this, since the check does not require the use of other planimeters whose instrumental errors are unknown. The rectangle is 10 by 7.5 ins. The curves which subdivide it are fair types of those met with in practice. Their areas were determined quickly under conditions not in any way exceptional. To increase the range, the three areas A, B and C were sometimes combined and measured as one. No results were rejected so that those given in the table following contain many of the errors which are

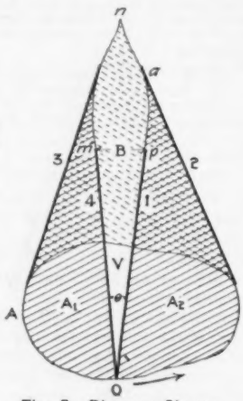


Fig. 2. Diagram Showing Relation of Width and Area of Tractrix to Area of Base Curve.

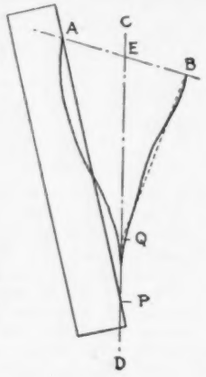


Fig. 4. Diagram Showing Method of Estimating Area of Tractrix.

likely to enter in using the method under working conditions. To eliminate compensating errors from the extreme sums, the results for each area are arranged in their order of magnitude.

Computed Areas in Square Inches.						
A	B	C	D	E	Sum	Error
25.05	27.05	1.12	15.50	5.55	74.27	−0.73
	53.32	[A + B + C]	15.53	5.55	74.40	.60
	53.30	"	15.53	5.56	74.59	.41
25.38	27.08	1.17	15.57	5.58	74.78	.22
25.51	27.37	1.17	15.76	5.62	75.43	+0.43

Favorable accidents were guarded against by redetermining the areas at various times, and by checking with Amsler planimeters. The results indicate that the probable maximum error is within the limit consistent with errors in plotting, tracing, etc.; so that the instrument and method may be used with confidence in practice.

The Tractrigraph is really an improved hatchet planimeter, and may be used with any method suggested for that instrument. The simplest of these, which was originally recommended by the inventor, Captain Prytz, requires that the instrument shall be initially set with its tracing point near the center of gravity of the area to be measured; the contour is approached along any path, traced, and the initial point regained over the same path. The area is approximately equal to L b, where L and b designate the same quantities as before.

A thorough test with the Tractrigraph on regular figures whose centers of gravity were available, showed that the other method described was by far the more accurate. The double error of locating the center of gravity and using it as an initial point, does not invite confidence in the results obtained; while in the method given the total error lies practically in approximating T, and may be estimated.

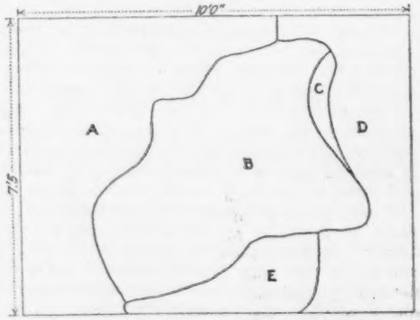


Fig. 5. Figure Used for Testing Accuracy of Tractrigraph.

Besides its pencil attachment, the Tractrigraph is mechanically superior to the different types of the hatchet planimeter on account of its perfect stability and its definitely measurable length of arm. The ease with which it responds to pressure of the guiding hand, and the distinctness with which it draws the tractrix, are features which add decidedly to its efficiency. There is no complicated mechanism to get out of order, and the effects of wear are of no account. The operation of using it, though apparently long and complicated, is really very simple, requiring at the most only a few minutes to compute an area. Just as with other engineering instruments, a little experience will enable the operator to get satisfactory results.

A curious property of the instrument was noticed while using it on very large areas. If the average line across the area is long in comparison with the length of arm, and the tracing point is dragged continuously around the contour, the tractrix will approach, asymptotically, a limiting closed curve. From purely empirical observations, it seems that this effect can be obtained so long as the length of arm does not exceed the radius of a circle of area equal to the area of the base curve. Theoretically, this property would make the Tractrigraph an absolute planimeter, since the limiting length could be obtained by trial. The area would then be πL^2. Unfortunately the time and patience required for this adjustment make the method unfit for practical purposes.

The writer is indebted to Professor Lehmer for many valuable personal suggestions which helped to bring the instrument to its present efficiency.

PETROLEUM FUEL FOR LOCOMOTIVES ON THE TEHUANTEPEC NATIONAL RAILWAY, MEXICO.

At the meeting of the Institution of Mechanical Engineers (of Great Britain) at London, on March 16, an interesting paper was presented on the use of oil-fuel in the locomotives of the Tehuantepec National Railway. The paper was written by Mr. Louis Greaven, of Buenos Aires, formerly Locomotive and Car Superintendent of the railway in question, and from it we have compiled the following information. Mr. Greaven points out that the fuel question in Mexico has always been a very serious one for railways and industrial establishments, as the only coal mined in Mexico is a small amount of inferior quality in the north of Mexico, while there is an ever-increasing cost of and difficulty in obtaining wood for fuel. These difficulties have led to the development of water-power for electric generating and transmission plants, and to the exploration for oil. The ultimate certainty of a supply of native oil appears to have been proved, but in the meantime the company which built and operates the railway (S. Pearson & Son, of London), has arranged for the importation of oil from the Beaumont fields in Texas.

At the Atlantic terminal of the railway at Coatzacoalcos, there is a steel storage tank 92 ft. diameter and 29.75 ft. high, having a capacity of 1,478,543 U. S. gallons. The bottom of the tank is about 20 ft. above the level of rails. At Santa Lucrecia (79 miles) and at the Pacific terminal of Salina Cruz (193 miles) are single auxiliary storage tanks of 28,200 gallons capacity, while two similar tanks are installed at Rincon Antonio (127 miles), where the main shops are located. These auxiliary tanks are of steel, 20 ft. diameter and 12 ft. high. The tanks were tested by filling them with water, and all leaks calked, but further repairs were found necessary to make them oil-tight. Oil is transported from the storage tank to the auxiliary tanks in steel tank cars of 6,600 gallons capacity. A 4-in. pipe line leads from the wharf to the top of the storage tank. The average cost of the oil, as issued from the railway stores department, is about $2.52 per barrel.

For the purpose of supplying engines and filling tank cars, a large storage tank at Coatzacoalcos is fitted with a 8-in. valve, from which is run an 8-in. main 300 ft. long to low lying or basin-shaped ground, and a second valve is provided at the extreme end of this main. The main runs through the station yard, and at a suitable point a branch is taken off to a stand-pipe or column, which is provided with a 6-in. valve; engines are supplied with oil and tank cars are filled at this column in much the same way as engine tanks are supplied with water. The object of having the 8-in. main carried out of the station yard to low-lying ground beyond and fitted with a valve at the end, is to provide a means for allowing the oil to escape from the tank in case it should take fire from lightning striking it, or from any other cause. The main valve at the tank is always open, and the outlet is controlled by the valve at the end of main and the stand-pipe valve. The tank being elevated above rail-level, the engine and traveling tank cars are supplied with oil by gravity.

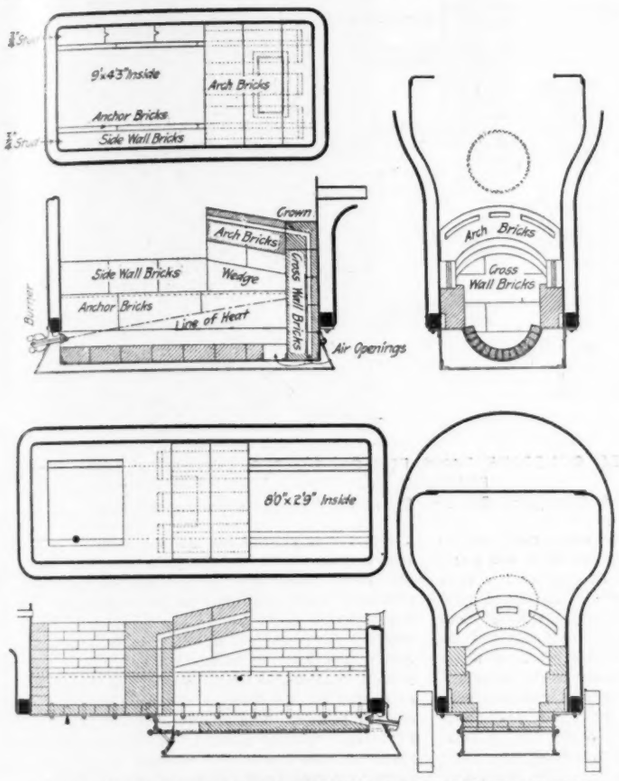


FIG. 1. FIREBOXES OF OIL-BURNING LOCOMOTIVE ON THE TEHUANTEPEC NATIONAL RAILWAY; MEXICO.

Engines are supplied with oil from the auxiliary station tanks in much the same way as water is supplied; a spout (4 or 6 ins. diameter) from the tank lifts and lowers by means of counterweights and knuckle-joints. It is very necessary to keep these joints properly ground in and oil-tight. Leather or rubber hose fixed at the end of the spouts is not suitable, as it drips too much, and the petroleum rots it quickly. There is a valve inside the oil tank, with a lever on top and a rod or chain outside the same, as is usual with a water-tank.

In some parts of the United States inclined tracks are constructed alongside station oil tanks, and the tank cars are run up the incline and emptied by gravity into the station tank. Another system also sometimes adopted is to construct a reservoir under the ground level into which the oil cars are emptied, and the oil is subsequently pumped into the station tank at leisure. For large railway systems these plans are undoubtedly the most efficient and economical, but the expense was not considered justified or necessary at the present time on the Tehuantepec Railway. A flat car was therefore fitted up with a 6-in. double-action pump and vertical boiler, the pump being provided with suitable piping and flexible hose to connect with the discharge pipes of tank cars, and to deliver the oil into station tanks.

The tenders of the ten-wheel passenger engines carry 3,000 gallons of oil (22,500 lbs.) and average 657.8 miles per tank of oil. A smaller converted eight-wheel engine averages 263.15 miles per tank of 1,200 gallons of oil as compared with 244.3 miles for a load of 10,080 lbs. of coal. The consolidation freight engines carry 1,200 and 1,987 gallons of oil (9,000 and 14,902 lbs.), and average 133.3 and 220.7 miles per tank of oil. The cost of converting a coal burning engine into an oil burner is about $1,411. Fig. 1 shows two of the fire-box arrangements used on the oil burners; a flat bottom is used in some of the engines, and an inverted arch bottom in others. It will be noted that in one case there is a bridge wall placed some distance back from the tube sheet. Fig. 2 shows the pipe connections to the burner. The comparative consumption and cost of oil, coal and wood fuel are given in the accompanying table.

There are many kinds of hydro-carbon burners, and amongst those with which the author has had personal experience are the Holden, Sheedy Carrick, Booth, Lahey, Best and others. One of the most essential points about a burner is the facility of keeping it clean and free from clogging, and another is its adjustability both for giving the right direction to the flame or spray and regulating the proper proportionate supply of steam or compressed air and oil. The most satisfactory results in these respects, and in the greatest economy of oil fuel, were obtained with the Best burner, which is very easy of access and adjustment.

There are some incidental advantages in using oil fuel apart from anything due to consumption. All clinkers, ashes, sparks, falling fire and choking up of front ends of smoke-boxes, are obviated. The weight of a gallon of oil is 7½ lbs., and in freight service 1,687 lbs. of oil are equal to 2,240 lbs. of coal, while in passenger service 1,857 lbs. of oil are equal to 2,240 lbs. of coal. As at least 75% of the consumption is in freight service, we can take a saving in weight hauled of 22¾% if oil-burning engines take oil as frequently as coal-burners have to take coal.

Another advantage of oil-burning engines is the facility and quickness with which steam can be raised in a locomotive. While it is not advisable to raise steam too quickly in any boiler in consequence of the sudden expansion of the plates being injurious, yet at times it is necessary in railway operation, and when necessary steam can be got up in less than an hour, whereas 2½ or 3½ hours is the usual time for getting up steam with coal.

Another advantage is obvious when an engine is detained for any reason on the road or reaches its destination with orders to turn back after the enginemen and trainmen get rest; the fire can be extinguished, so that during the time the engine is standing there is no consumption of fuel, while an engine in fair condition will always retain sufficient steam pressure to start the burner after standing for several hours; any danger to the boiler or fire-box in consequence of water falling too low while the engine is standing is also obviated. A coal-burning engine will consume during a lay-over of ten hours 220 lbs. of coal at least, which represents over $1.70 for which no useful return is obtained.

One of the most important points to observe in oil-burning boilers is the condition of the fire-brick work. Good fire-bricks and good bricklaying are very necessary; ordinary fire-bricks such as are used in furnaces are not always suitable, as the heat of the oil fire is very intense. Large blocks should be used in the arch, and blocks 9 × 4½ × 2½ ins. in the sides and front wall. With first-class materials and workmanship the brickwork in a locomotive may last a year without removal.

Experience, so far, does not indicate any detrimental effect or injury to fire-boxes; no leakages have been found either in the new engines or in the old engines which have been converted from coal-burners. If the fire-brick work is very carefully looked after and kept in good repair, the injury to the fire-boxes (if any occurs) will be reduced to a minimum. As the heat of an oil fire is more intense than that of coal, the injurious effects on oil-burning fire-boxes may be greater than on coal-burning fire-boxes. Copper fire-boxes stand the excessive heat better than steel, in consequence of their greater adaptability for contraction and expansion. A slight distillation of the crude oil, where this is possible, eliminates to a considerable extent the deleterious effects of its combustion upon heated steel. The presence of sulphur in crude oil is, of course, liable to cause corrosion of fire-boxes, but if the percentage of sulphur is limited to, say 2%, the injury done is very little more than when burning coal. During the twelve months that oil has been used there have been no troubles with fire-boxes which can be attributed to the use of oil fuel.

Fire-boxes need greater care and attention when oil fuel is used, and a great deal depends on keeping the fire-brick work in sound condition. An engine should never be allowed to go out with a defective arch or a broken wall, and if proper care and attention are given the life of a fire-box of an oil-burning engine is very little shorter than the life of that of a coal-burner.

None of the enginemen or firemen had any experience in burning oil on locomotives, and yet no difficulty whatever was experienced in teaching them and inducing them to take an interest in the new fuel. With the assistance of a competent instructor from the International & Great Northern Ry. of Texas, most of the men soon understood the handling of oil-burning locomotives; and the instructor stated that he found Mexican firemen very apt pupils.

CONSUMPTION AND COST OF FUEL FOR LCOMOTIVES: TEHUANTEPEC NATIONAL RAILWAY.

	OIL		COAL		WOOD	
	Pass.	Freight.	Pass.	Freight.	Pass.	Freight.
Consump. per eng. mile....	4.56 gals. 34.2 lbs.	9.00 gals. 67.5 lbs.	41.25 lbs.	80.6 lbs.	6.26 cu. ft.	10.87 cu. ft.
Engine miles	(1) 9.2 per bbl.	4.7 per bbl.	(2) 54.3 per ton	25.0 per ton	.....	.....
Train miles	8.7 per bbl.	4.4 per bbl.	52.6 per ton	22.0 per ton	(3) 10.4	6.3
Cost per engine mile.....	27.4 cts.	53.6 cts.	32.4 cts.	69.2 cts.	33.6 cts.	58.0 cts.

(1) Oil, 7.5 lbs. per gallon; one barrel = 42 gallons.
(2) Gross ton, 2,240 lbs.
(3) Per "tarrea" of 72 cu. ft.

THE MADISON RIVER PROJECT NEAR HELENA, Mont., has been reported on by the engineers of the U. S. Reclamation Service. The proposed works, which would supply water to nearly 150,000 acres, would include a storage dam in the Madison River Canyon, water from which would be discharged into Madison River. A weir about seven miles below the dam, near the mouth of Cottonwood Gulch, would divert water into a canal heading on the west bank of the river. This canal would continue along the river for about 30 miles, would cross Jefferson River by a siphon more than three miles long, near Willow Creek, and would then parallel the west bank of the Missouri River at some distance and finally discharge into McClellan Creek. The channels of McClellan and Prickly Pear Creeks would be used for about 2½

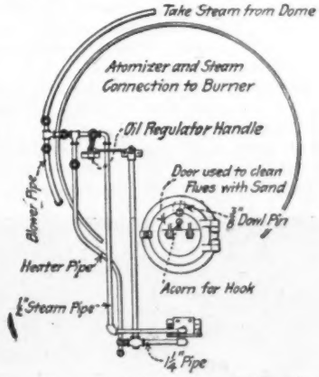


Fig. 2. Pipe Connections of Oil-Burning Locomotive.

miles of the length of the canal. The total length of the canal would be 150 miles and would include 16 miles of tunnels, 27¾ miles of concrete-lined sections, 4 miles of siphon pressure pipe, 99½ miles of earth canal, and 2½ miles of natural stream channel. The difficult character of much of the construction brings the total estimated cost of the project up to $14,413,000, or an average of $97.50 per acre for the 147,800 acres which it is proposed to water. Maintenance and operating charges of $5 per acre for 10 years would increase the cost to land owners to $102.50 per acre.

REINFORCED CONCRETE GAS-HOLDER TANK FOR THE KEY CITY GAS CO., DUBUQUE, IA.

A gas-holder tank of reinforced concrete, 84 ft. in diameter and 21 ft. 5 ins. deep, was constructed about a year ago for the Key City Gas Co., of Dubuque, Ia. This tank, while not remarkable in point of size when compared with other examples of circular tank construction (including storage reservoirs and gas-holder tanks) in the same material, affords a good example of a carefully-planned method of work in erection. This is briefly described in the present article, after information furnished us by Mr. John E. Conzelman, Assistant Engineer of the Expanded Metal & Corrugated Bar Co., of St. Louis, Mo., who designed and built the tank.

GENERAL DESCRIPTION.—The general construction of the tank is indicated by Fig. 1. The bottom of the tank is 5 ft. below the average grade of the site. The floor is normally 16 ins. thick and rests on piles spaced about 4 ft. 6 ins. on centers, but under the wall it is 28 ins. thick and the pile spacing is reduced to 2½ ft. The floor rests directly on the piles [although a foundation of cinders and sand well mixed and tamped was put in between the pile-heads] and is reinforced only around the edges and under the center pier. Below the floor are two reinforced concrete tunnels for the outlet and inlet pipes. The wall is 21 ft. high, 18 ins. thick at the floor line and 12 ins. thick under the cornice. The center pier is made of reinforced concrete as indicated in Fig. 1. For the floor a 1-2½-5 limestone concrete was used; the stone all passed a 2-in. ring and had the dust removed. This mixture was also used for the cornice. The concrete for the walls was a 1-2-4 limestone mixture; the stone all passed a 1-in. ring and had the dust removed.

The size and location of the reinforcing bars are clearly indicated by the drawings of Fig. 1. The reinforcement is all corrugated bars. The circumferential bars were spliced by lapping; they were placed in lengths two bays long, the inside bars so as to lap alternately at pilasters and middle of bays, and the outside bars so as to lap alternately at piers and middle of bays.

The general plan of construction was to put in the floor complete, leaving in it a groove or trench to take the bottom of the wall, molding in the floor also supports for the frames of the wall molds, as the soft foundation material made it undesirable to rest the mold-frames on the ground; then to build the wall between forms which could be moved up as the work progressed, the complete circle of the tank being filled to the height of the form in one operation, thus making all joints in the work horizontal. The back-fill around the lower part of the wall was relied upon in the design as a support for the wall, and it was therefore carefully tamped in after the wall was completed. The following is a description of the methods in detail:

FLOOR CONSTRUCTION.—The first work in constructing the floor was to drive the piles in the bottom of the excavation and then to place the bed of sand and cinders. This being done two circumferential rows of posts were driven around the outer edge of the foundation bed.

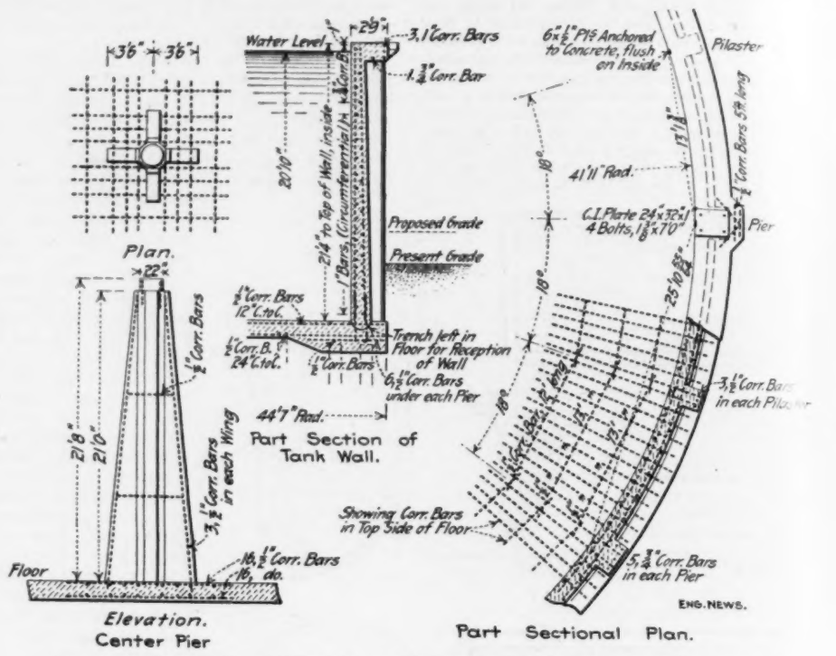


FIG. 1. REINFORCED CONCRETE TANK FOR GAS-HOLDER, KEY CITY GAS CO., DUBUQUE, IA.
Expanded Metal & Corrugated Bar Co., St. Louis, Mo., Designers and Builders.

The posts were located on the same radii as the wall buttresses. The upper portions of the posts were boxed around so that, in placing the concrete for the floor, recesses would be left around the tops of the posts, which would enable them to be cut off below floor level and covered by filling the recesses. The purpose of these posts was primarily to carry the frame bents on which the inside wall forms were carried progressively upward. The lower half of each post was notched, to form a bond with the floor concrete, whereby the load of the mold-frames would all be carried by the latter. Incidentally the posts carried the forms for the circular groove or trench in which the wall was seated, as shown by Figs. 2 and 3.

To the tops of each pair of posts, radially of the tank, were nailed two planks with ends projecting beyond the outer edge of the floor, as shown by Figs. 2 and 3. To the projecting ends of these planks were fastened cleats extending downward, and onto these cleats were bent two lines of 1 × 6-in. boards forming a circular, bottomless trough around the tank space as the line of the wall. Small strips of board were then nailed across the top of the trough on equidistant radial lines, and from these were suspended two lines of vertical wall bars. The trench forms being in place, concreting was begun. The concrete was put in in sections, forms being provided for stopping off the day's work. These forms served the double purpose of making a mortise-and-tenon joint between successive day's work, and, by setting the tops of the forms to exact grade, of templets between which the concrete could be floated level with straight edges. The object of the mortise-and-tenon joints was both to insure watertightness and to give a continuous beam action, the forms being so placed as to subdivide the floor into diamond-shaped panels. The concrete was handled from the mixer to the work in wheelbarrows; when placed it was thoroughly tamped, roughly floated to surface and finally given a trowel finish.

WALL CONSTRUCTION.—As shown in Fig. 1 the tank wall is buttressed on the outside by alternate "pilasters" and "piers." The piers support the columns for the guide frame, while the pilasters, intermediate between the piers, "support the cornice and break the outline of the tank, giving a more pleasing appearance." The wall was constructed as follows:

After the floor was completed, the posts driven into the bottom, as before noted, were cut off level 6 ins. above the floor and a bent for the wall form was erected on each radial pair. The construction of these bents is shown by Fig. 4. Each bent was raised by hand and was carefully plumbed and centered; the proper angular distance between bents was assured by setting each bent on a line from the center of the tank to a previously set point on the peri-

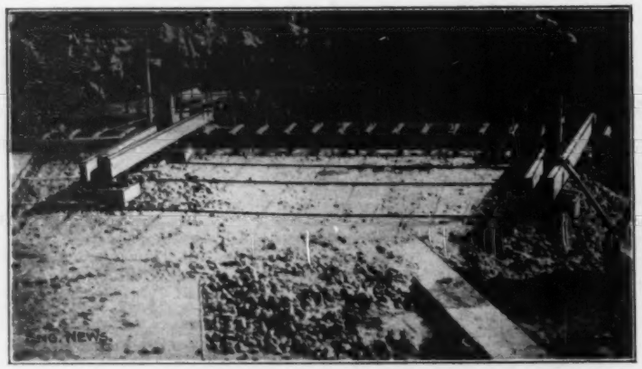


FIG. 2. FLOOR OF REINFORCED CONCRETE TANK FOR GAS-HOLDER, DURING CONSTRUCTION.

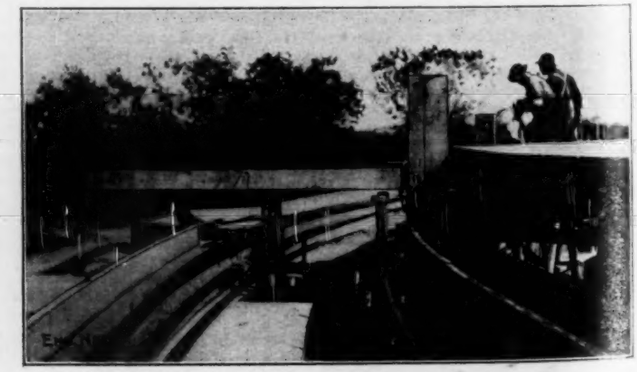


FIG. 7. VIEW SHOWING CORNICE MOLD, AND INNER FORMS IN HIGHEST POSITION.

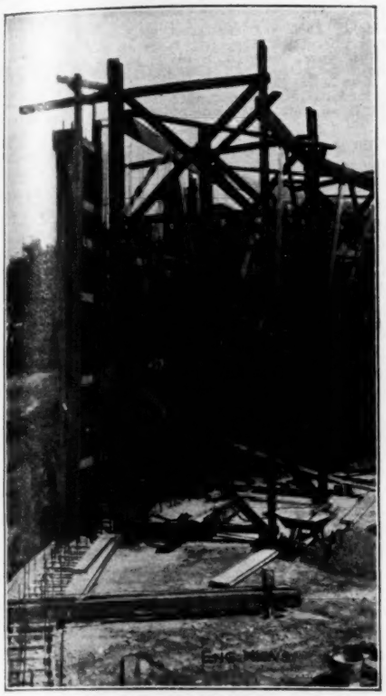


Fig. 3. Scaffold Frame for Inside Wall-Forms, and Pilaster Mold.

phery of the floor. The bents were braced together around the tank as shown by Fig. 3. The pilaster and pier forms were next set in place directly in front of the bents and braced in position. A pilaster form in position is shown by Fig. 4. These forms were boarded up completely on the two sides, but the rear face boards were placed only after concreting was begun and as the concrete was laid.

To mold the panels between the pilasters and piers and the corresponding spaces on the inside of the wall curved sectional forms or shutters were inserted between and fastened by the edges to the pilaster forms on the outside and to the bents on the inside. A shutter for the inside of the wall is shown by Fig. 5. The outside shutters were exactly similar except, of course, they were concave instead of convex; one of them is shown in position by Fig. 6. In operation the shutters were first set up with their bottoms on the concrete floor. The edges of the inside shutter were bolted to the sides of the wall posts of the bents; this left between the posts and the edges of the shutters triangular spaces which were closed off by vertical 2-in. straps of steel fastened to 1 × 1-in. strips of wood. The edges of the outside shutters were lag-screwed to the 4 × 4-in posts of the pilaster forms. The face-sides of the shutters were oiled with crude oil when set and again after the first shift, but it was not found necessary to oil the forms for every move. The forms were 4 ft. high and they were raised 3 ft., leaving 1 ft. of the lower part lapping over the finished concrete. The forms were raised by means of blocks hung from a 6 × 4-in. timber placed across the top of the adjacent bents and pilaster forms. Forms were shifted the day after placing the concrete. At first it took almost a full day to get the forms for the full circle into their new position, but after two shifts this time was reduced to half a day. Much of the delay was due to the ½-in. bolts tying the inner and outer molds together at the intermediate verticals (see Fig. 5), which bolts became bent and were very difficult to remove. Mr. Conzelman says, on this score:

> These bolts were ½-in., threaded at each end, and were too light. If bolts are used they should preferably be ¾-in. diameter. It is desirable to use bolts instead of twisted wire ties as it is necessary to draw up the lower set of ties well in order to clamp the bottom of the molds to the previous day's work.

The 6 × ½-in. vertical steel strips molded in the inside face of the wall at each pier and pilaster, shown in Fig. 1, were used in connection with the mold frames as follows: The plates were bolted to the outside face of the frames, covering the 6-in. space between the two uprights of each frame, being bolted in such position as to bring their inner face flush with the outside of the frame (or the inside of the wall). Anchors fitted to these plates at intervals of 3 ft. serve to hold them firmly to the wall. During construction this rigid connection between frame, plate and wall acted to hold the frame firmly in place, so that the diagonal bracing of each bent could be removed to make room for wheelbarrow runways.

The runway on the inside rested first on the second horizontal of the frame, and the concrete was dumped, from a platform outside, through the bars upon a platform on the runway; thence it was taken by wheelbarrow and dumped into place. The runway was raised to successive horizontals as the work progressed.

The cornice of the wall was formed by an outside mold, shown in photograph Fig. 7. The outside shutters were moved up until in contact with the bottom of the cornice mold, and the inside shutters were raised to the height of top of cornice, thereby completing the mold.

REINFORCEMENT.—The sizes and distribution of the reinforcing steel are given by Fig. 1. The placing of the floor reinforcement has already been referred to. The wall reinforcement was all placed and wired up before the wall concreting was begun. This work was relatively simple. The bars came in lengths of about 30 ft., and this gave a lap of about 3 ft. on the circumferential bars, the laps being located at every second division, as already noted. The

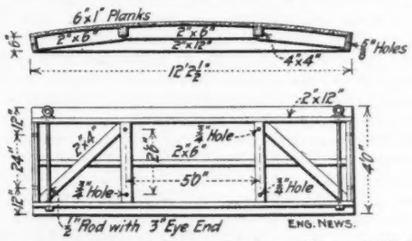


Fig. 5. Section of Forms for Inner Face of Wall.

lapping ends of the circumferential bars were first loosely hooped with two ties of No. 10 wire, then the verticals were placed, and the circumferential bars were then pulled up to their proper levels and wired to the verticals. The lapping was done in such a way as to allow the concrete to surround each bar, as reliance for splicing was placed wholly on the concrete.

SOME COST ITEMS.—The cost of unloading the reinforcing steel from the cars and placing it in the structure was $7 per ton. The labor of mixing and placing the concrete amounted to 3.4 hrs. per cu. yd. for the floor, 5.2 hrs. per cu. yd. for the wall (including pilasters and piers) and 5.4 hrs. per cu. yd. for the cornice.

The cost of the forms cannot be expressed so satisfactorily. Generally speaking, and making no allowance for value of lumber after use, 9 cts. per sq. ft. of wall would cover the cost of materials, fabrication, taking down and putting up the forms.

A RUSSIAN OPINION OF THE QUALITY OF STEEL RAILS.

The quality of steel rails has been a subject of earnest discussion for some years past in this country among men interested in the use of steel, principally among rolling mill engineers and railway engineers of test and maintenance. A main question at issue is the "soundness" of rails—a somewhat ill-defined quality related to the resistance of the rail to sudden failure by crushing. Form of section and resistance to normal wear have been but minor factors in the discussion.

Some opinions on rail quality from the standpoint of Russian experience are timely reminders that trouble with rails is by no means confined to the United States or to American steel. These views are contained in an article on rail wear by Mr. L. von Lubimoff, Chief Engineer and Assistant General Manager of the Nikolai Railway, printed in a recent issue of the "Organ für die Fortschritte des Eisenbahnwesens." The author considers the rail problem to be one of proper *grade* of steel. He says:

> The acceptance of too soft steel, which entrained a relatively high wear of the rails, was recognized as a mistake, even in the '80's. . . . . The rail steel of the recent years 1900 to 1905 has given even worse service than the former, and occasionally in such a degree that a government board has now been appointed for the purpose of compiling the technically most perfect specifications for rail steel.

Russian rail steel is made principally by the Bessemer process, both acid and basic, and only few of the works employ the open-hearth furnace. The average requirement for rail steel is a minimum tensile strength of 60 kg. per sq. mm. [85,000 lbs. per sq. in.] a minimum elongation of 6% minimum, and a minimum value of 82 for the sum of tensile strength [in kg. per sq. mm.] plus twice the elongation [in per cent]. Bending and impact tests are also prescribed in all Russian rail specifications. The rails of 1900-05 all meet these specifications, but they exhibit in service a large and irregular wear, and such faults as mashing of the head [at joints as well as elsewhere in the rail], shallow depressions crushed into the head of the rail at various points, faulty welding as exhibited by long grooves several millimeters deep in the rail head, exfoliation, cracks and blow holes [chargeable to piping], etc. These faults have been observed markedly in 85-lb. rail recently furnished for the lines between St. Petersburg and Moscow and between St. Petersburg and Warsaw.

HARDNESS AND BREAKING OF RAILS.—It is observed on various Russian railways that rails of relatively soft grades of steel show frequent failure by fracture as well as by other defects. Some illustrative figures show that rails varying from 88,000 lbs. per sq. in. tensile strength, with 18% elongation, to 116,000 lbs. with 11% elongation, showed unusually bad results. On the other hand, much harder rails have given excellent service—and this in spite of the fact that in Siberia very low temperatures are met in winter and temperature variations as high as 70° F. in 12 to 18 hours occur. A shipment of English rails of hard steel, laid on the Siberian railway in 1894, has given excellent service, showing only two breaks in the period 1894-1902, as against over nine thousand breaks

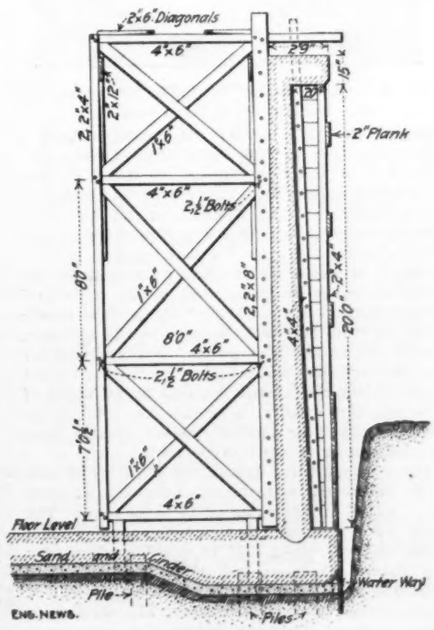


Fig. 4. Details of Frame for Inside Wall-Forms.

of rail on the whole of the Siberian railway. Equally good results are quoted for an earlier lot of English rails of 0.84% carbon, laid on Russian railways from 1870 to 1875. [Apparently the track inspection on the Russian railways is given exceedingly careful attention. Figures for three railways, covering five to ten years, show that a derailment occurs only once in every 1,100 to 1,700 rail fractures.]

HARDNESS AND RAIL WEAR.—A number of rails from six Russian rail mills, with carbon percentages 0.28 to 0.77, were laid in a stretch of track in 1889, for a comparative observation of rail wear. The cross-section of these rails was measured in 1890, 1898 and 1903, and the wear was measured and reduced to wear per million tons of traffic. The results in amount of wear divide these rails into two fairly definite classes: the better class shows wear coefficients varying from 0.021 to 0.042, while the other class gives figures from 0.063 to 0.079, with one exceptional figure at 0.130. The tensile strength in the better class varied from 62,000 to 132,000 lbs., averaging 97,000; in the poorer class from 75,000 lbs to 113,000 lbs., averaging 92,500. Thus

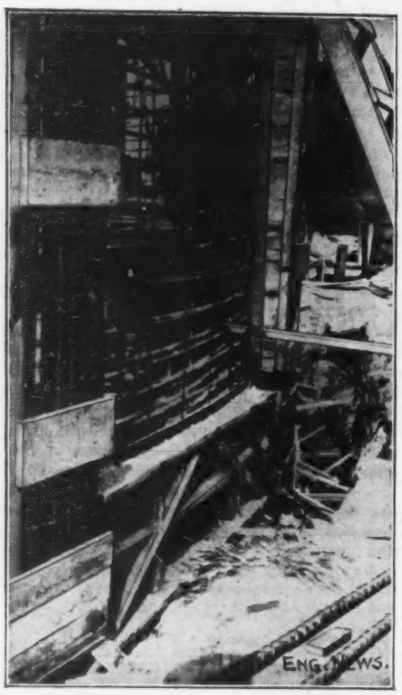


Fig. 6. View Showing Wall Reinforcement and Section of Outer Form.

the tensile strengths do not seem to bear a direct relation to the wear. The carbon percentages in the two classes are 0.39-0.77, and 0.28-0.52 respectively. The record is incomplete as to results of the Brinell test for hardness. The figure for tensile strength plus twice elongation is about the same for both classes; if anything, it is higher for the bad rails than for the "better" rails; in fact, the lowest individual figures appear in the "better" class. The elastic ratio, or ratio of elastic limit to tensile strength, which the author also quotes, averages 0.59 for the "better" rails and 0.50 for the "poorer" rails; he considers this elastic ratio to be an index of the wearing quality, although the differences between the wear figures are far greater than the differences of the elastic ratios.

Other comparative figures are given for 90 rails taken out of the main track of the Nikolai Railway in 1904 after service of 13 to 35 years. The rails were from Russian, English and French mills, and contained 0.32 to 0.84% carbon. By the Brinell hardness test they showed values from 175 to 277 for the top of the head. All of these rails gave excellent results; 73% showed no trace of local crushing, while the maximum crushing in the remaining 27% was 0.05 mm. depth per million gross tons traffic. The elastic ratio for the individual rails varied from 0.49 to 0.82. The rail showing the minimum wear in this series was the one of highest carbon [0.84%], highest hardness by Brinell test [294], and highest elastic ratio [0.82]. Selecting those rails in his tables which showed the best individual results, the author concludes that satisfactory service may be expected of rails having carbon higher than 0.45%, Brinell hardness not less than 200, and elastic ratio not less than 0.50. Beyond these requirements, he says, further reliance for good service must be placed on excellence of manufacture and rolling, particularly in the matter of heat control in rolling. The simplest and most reliable single indication of wearing value, the author believes, is the ratio of elastic limit to ultimate tensile strength.

REPORT TO THE NATIONAL BOARD OF FIRE UNDERWRITERS ON THE SAN FRANCISCO CONFLAGRATION.

The conflagration which destroyed part of San Francisco, Cal., on April 18 to 21, 1906, has been studied for the Committee of Twenty of the National Board of Underwriters by Mr. S. A. Reed, Consulting Engineer, and a report of this study has now been submitted by the latter. The report contains much matter of great interest in fire protection, but as it is a document of considerable length we are able to reproduce here only brief extracts from it. Much of the descriptive information concerning the actions and results of the fire resides in the photographic views appended to the report, of which there are no less than 136, but for these as well as the full text we must refer to the report itself.*

Our quotations from the report will be confined mainly to the matter dealing with the effects of the fire on the buildings of the so-called "fireproof" class. Not the least valuable part of the report is a full list of these buildings, with a summary of the present condition of their essential structural and fireproofing elements, which is reproduced farther below.

It will be remembered that the San Francisco conflagration began almost immediately after a violent earthquake, which occurred about 5.13 a. m., of Wednesday, April 18, 1906; the fire continued, as a conflagration, for about three days, and in that time swept over an area of 2,381 acres (=3.72 sq. mi.), which included the business district and a large part of the dwelling district. The property loss has been estimated as at least 80% of the property value of the city before the fire.

The report of Mr. Reed gives a brief explanation of how the fire was limited or stopped:

> At and within fighting range from the waterfront, the Inlet, and Centre's Tank, on the south, a successful defence was made on account of the ability to get water, the opportunity for safe retreat and for reinforcements, and finally on account of the assistance of pumps on vessels. The inland limits of the conflagration were determined by a variety of causes. First, on the south and southwest, by a windward position, and a thinning out to scattered low-lying frame construction. Second, on the west, near the line of Van Ness Ave., by a desperate stand made by the Fire Department in co-operation with men from the U. S. Army and Navy, with extensive dynamiting and back-firing. The essential causes, however, were, first, a change of wind, and, second, the presence of water all along this line, from the Buchanan St. mains and from the military and naval hose-lines stretched 2,000 ft. from the Bay down Van Ness Ave., and supplied by the Quartermaster's tug. There were also numerous cases of individual defence by citizens which contributed to the check on the southwestern and southern borders.

It is readily understood that the work of fighting the conflagration, after the fire once got beyond control, was a forlorn hope, and had little relation to the termination of the conflagration. But even the earlier efforts of the Fire Department were ineffective because of the virtual destruction of the water distribution system by the earthquake. Another factor, also, the simultaneous outbreak of fires at many different points (not proved, but a reasonable conclusion), made the early defence difficult; yet, Mr. Reed says:

> Judging from the successful work which was done during this period [the early hours of Wednesday—Ed.] on fires which occurred in places in the third service, where some water could be obtained, and having in view the lightness of the wind and its direction, it is a reasonable presumption that had water been abundantly available the Fire Department might have obtained control by noon of the first day.

This makes it of interest to note what conclusions are presented in the report as to the possibility of a system of water supply and distribution which will survive such violent attack as that of the April earthquake:

> The real issue will continue to be whether any system of underground pipes can be relied upon to survive a shock equal to this one. If not, then the most perfect distributing system and the most reliable, abundant and powerful sources will be useless. * * * Even a more perfect system of gates, whereby crippled portions may be cut out, would not meet the requirements for a panic-proof as well as earthquake-proof water service. During the first hour of the fire there were 80,000,000 gals. of water in the three reservoirs within the city limits, being rapidly drawn down, of course, by the breaks, but at any rate the point is clear that a shortage of water was not the difficulty. There is no escaping the conclusion that even if San Francisco had had the most perfect water system that can be devised, under ideal management, and with conduits and reservoirs undamaged, yet the breaks of underground distributing pipes, even at a few places, occurring as they would all at once at the critical time, viz., the outbreak of the fire, would have been followed by results not materially different. Salt water mains would have been equally crippled. Steel pipe would not have survived better than cast-iron, breaks involving sheer drops of 3 and 4 ft. in the street grade. There is no doubt that the liability to extensive damage may be reduced considerably by observing certain lessons of this event. Omitting, for the present, any consideration of apparently well-founded theories as to the existence of a fault or line of weakness running through the solid formation on a line from Lake Merced to and through San Andreas Lake, which line of weakness should be avoided by future conduits, and confining ourselves merely to considerations which are quite obvious from observations of damage done within the city limits—not only to water pipes, but also to sewer and gas pipes—it is clear that a large part of the liability to damage may be avoided by deep foundations for pipe lines where laid through soft formation. It will also doubtless be possible to make future house connections in a manner less liable to fracture in case of earthquake. Still, in spite of all these possible improvements, there will be a residuum of liability whose seriousness cannot be ignored. The bleeding of water systems by broken house connections is a familiar difficulty during conflagrations; but they usually occur progressively, as one building after another is wrecked by the spread of the fire, and it is conceivable that a highly organized gate manipulation would keep pace, to a certain degree, with the wastage of water; but the case is different where most of the damage occurs instantly. The particular difficulty of broken house connections can, of course, be met by a separate fire main system, but the latter would itself still be liable to break. The conclusion cannot be avoided that, if San Francisco is to have in the future a degree of security on the subject of water supply reasonably approximating that of other cities, the regular pipe system will have to be supplemented by a supply of some kind independent of any underground pipe system.

It is clear, from this alone, that San Francisco must depend in large part on real fire-resisting construction of its buildings (and proper guarding of the inflammable contents) for its safety against conflagration. Therefore, if the lessons and recommendations which the great fire yielded have value anywhere, they have greatest value in San Francisco itself. But, of course, their importance to fire-protection is quite independent of any localized value.

STRUCTURAL CONDITIONS.

The fire-risk at San Francisco before the earthquake, as concerns construction and grouping of the buildings, is described as follows:

> San Francisco was 90% frame, a larger proportion than that in any other city of its size in the country. The fire limits for frame buildings approached unusually close to the business section, and the congested district itself included 30% of frame buildings of older date. Frame buildings of a considerable height, four to five stories, were common. The dwelling district was almost entirely frame, large sections being not scattered, as is usual in frame dwelling districts, but in compact blocks. In the congested district 75% of the streets were 60 ft. and over in width, and about 30% were 80 ft. and over. Construction was generally poor in the older buildings; but better methods were followed in more recent construction. Buildings other than frame were classified, under the building law, into: Class A, fireproof; Class B, wooden-joisted brick with metal lath; and Class C, wooden-joisted brick with wooden lath. There was a height limit for each class, viz., Class A, 220 ft.; Class B, 100 ft.; Class C, 82 ft.; frame buildings, 45 ft. The permission thus allowed for wooden-joisted brick buildings to be carried up to eight stories, provided they had wire lath and plaster ceilings under the joists, indicated an amount of faith in that type of protection not generally shared by underwriters.
>
> There were, at the time of the fire, about 54 fireproof buildings in the city, six of these being in course of construction. The heights were as follows, including those in course of construction: Three were 15 stories and over, 14 were 10 to 12 stories, 9 were 8 and 9 stories, 18 were 4 to 8 stories, 10 were 3 stories and less. Buildings with floors of mill type were two outside the business section, two of modified mill type in the business section.
>
> The National Board engineers reported about 50% of buildings shuttered, generally non-standard and with front openings seldom protected. They also criticised the

*Mr. S. H. Lockett, 135 William St., New York, N. Y., was Secretary to the Committee of Twenty, and inquiries may, we presume, be addressed to him. We understand, however, that this committee has been superseded by another, the Committee on Fire-Prevention, of which Mr. W. E. Mallalieu, also of 135 William St., New York, is Secretary.

lack of protection to wall openings in fireproof buildings. The same criticisms have been found applicable to most cities in the country and have apparently been justified in this event.

The brick-built district extended not more than two or three blocks south of Market St., and the district beyond was almost wholly frame. The frame feature, of course, greatly facilitated the rapid spread of fire; but there is only slightly greater liability to interior fires in a frame than in a brick building, and the development in the brick building may be quite as rapid.

After describing in some detail the progress of the fire during its three days of burning, the report states the following general results:

Within the burned area of 2,381 acres there survived in a partly habitable condition:

(1) Three groups, i. e., a hill-top group of detached dwellings on Russian Hill, a group of warehouses at the foot of Telegraph Hill, and a mercantile group near the Custom House.

(2) A factory plant, i. e., the Western Electric Co.'s branch, the California Electric Co.

(3) Three U. S. Government buildings, i. e., the Mint, the Post Office and the Appraisers' Building; also part of the Hall of Justice.

(4) Two fireproof office buildings, i. e., the Hayward or Kohl Bldg., with a three-story building adjoining, and the Atlas Bldg., with a two-story building adjoining.

There also survived, in uninhabitable condition, but generally with structural integrity, all but four of the other fireproof buildings, namely 38, of which 15 were mercantile and the rest of office or dwelling occupancy; also six steel frames of unfinished fireproof buildings. There was but one fireproof building of over two stories in height totally destroyed, the Altamont Apartment House, which was dynamited.

Within the burned district not only did all frame buildings succumb, but also all brick buildings having wooden floor-beams succumbed, whether their construction was good, bad or indifferent of its kind, and with more or less complete structural ruin in nearly every case except that of the Palace Hotel.

The temperatures prevailing in the San Francisco fire were doubtless fully as high as those in the Baltimore fire. In the latter there were no cases where iron was melted, except that in one or two instances cast-iron parts bore traces of incipient fusion at edges; wrought iron or steel in no case showed any evidence of incipient fusion [John R. Freeman]. At San Francisco, Mr. Reed says:

Cases of melted iron [cast or wrought?—Ed.] were seen, and many of melted glass and of brass. On the upslopes of streets the basalt paving stones were frequently heavily spalled over entire blocks. Cable slots are extensively closed, more frequently by heat than by the earthquake; the Geary St. cable railroad was, for example, operated for an hour after the shock, several cars going over the line.

The definite statement as to "cases of melted iron," would give the San Francisco fire a distinctly higher temperature than the Baltimore fire. A similar conclusion might be drawn from the fact that a very large number of failures of steel columns by crushing and telescoping are reported from San Francisco, while only one or two occurred in Baltimore, the relative numbers being out of proportion to the relative numbers of steel columns involved in the fire. Moreover, the larger area of business district which was burned over at San Francisco, in not much longer time than the duration of the Baltimore fire, would make it reasonable to presume, from the greater amount of material burning simultaneously, that higher temperatures were attained.

FIRE PROTECTION DATA.

CONFIRMATORY TEACHINGS.—The report mentions a number of previously-recognized facts of fire-protection or fire-defence which found marked confirmation at San Francisco. Not all of these relate to protection directly, but for the sake of completeness we quote all:

(a) The paralyzing effect of a number of simultaneous fires.

(b) The weakening of the fire-fighting force as it thins out over a wide front.

(c) The impossibility, with existing methods, of front resistance to the sweep when the wind velocity exceeds a certain critical figure.

(d) The special vulnerability of leeward upslopes.

(e) The futility of explosives, except where there is close co-operation with hose streams.

(f) The structural ruin in conflagrations of all wooden joist brick buildings where the stability of the walls in any way depends upon the bracing by the beams.

(g) The structural ruin to be anticipated in conflagrations in all wooden-joist brick buildings where the wall bracing depends upon unprotected iron and steel girders or columns.

(h) The limited utility in a conflagration of rear and side shuttering where front windows remain unprotected.

(i) The ignitibility in conflagrations of ordinary roofs, consisting as they do of wooden boards with a thin veneer of tin or other roofing material.

(j) The slight value as conflagration breaks of fireproof buildings when abandoned.

(k) The possibility in conflagrations of holding buildings even with unprotected openings, provided there are some men, even a little water, *and the openings are few.**

(l) The little reliance to be placed on street widths as positive conflagration fire-breaks.

(m) The structural survival, even without window protection and when abandoned, of steel frame buildings with fireproof floor arches, provided the steel frame is properly encased with fireproof material; the structural damage being in close proportion to the excellence of the frame protection.

(n) The more or less complete destruction, in such buildings, of all non-structural interior; heavy spalling of all kinds of facing stone, with little distinction as to kind; the injury to ornamental moldings and copings; extensive damage to hollow tile in floor arches and partitions as ordinarily constructed; a marked increase of injury where wood finish floors are used over the floor arches; the danger from falling safes where there is loose back-filling; the failure of unprotected cast-iron mullions and spandrels in courts, and the weakness of roofs carried on unprotected steel rafters with suspended ceilings.

MILL CONSTRUCTION. — Nothing was learned in regard to mill construction. Two buildings with mill floors were saved by fighting on the inside [Western Electric Co., Pacific Hardware Co.]; several with modified mill floors were total losses, there being no inside fire-fighting force.

WOOD-JOIST BUILDINGS.—The universal destruction of wood-joisted buildings has already been noted. But in some of these buildings the walls remained standing in whole or in part, "due in every case to adequate thickness, good bonding, and good cement mortar." The value of these walls lies not in the salvage, but in the fact that

a brick wall which will stand up after the floors have burned out is properly regarded as of no small importance in contributing to a possible check of a conflagration.

The value of such surviving walls, in ordinary fires, in confining the fire to the building or even to the compartment of its origin, must also be borne in mind here.

The survival of columns and girders of cast-iron and steel in a wood-joisted building is another matter of importance. Some buildings had protected columns, which survived, giving proof that if both columns and (main) girders had been well protected by fireproofing, the frame and walls might have remained in place, while floors and joists burned away, so that

it might have been possible to restore the containing building as it stands, and thus effect a material salvage, perhaps as high as 20% in the case of an ordinary, plain mercantile building.

In discussing this type of building the Palace Hotel must be mentioned. This building was designed with special attention to earthquake resistance; massive exterior and cross walls of good workmanship sectionalized it into cells of moderate area, and iron rods in the masonry tied the walls together. The building was relatively little damaged by the earthquake, and after it burned out the walls were left standing in excellent condition. Practically all floor beams were wall-supported without columns or girders, which with the unprotected window-openings made the destruction of all but the walls a certainty.

FIREPROOF BUILDINGS.

The behavior of the buildings of modern "fireproof" type was closely the same as that of corresponding structures at Baltimore. The most marked difference was in the relatively greater number of column failures at San Francisco, all of which took the typical form of a mashed or bulged telescoping failure so well exhibited in the Calvert Bldg., at Baltimore (Eng. News, Feb. 25, 1904, p. 171). The present report contains half a dozen views of such failures at San Francisco, some views showing two or three failures in a single floor. It is estimated that no less than 50, and possibly well toward 100 such failures occurred in San Francisco. They frequently occurred in the basement story, though some appeared in floors near the top. Every column failure caused a sinking of the corresponding point in the building for all floors above, and in numerous instances the surrounding floor panels were destroyed by the distortion or subsequently fell out.

Some lessons on details of the protection of these buildings are quoted below, but we call attention first to the catalogue of fireproof buildings and extent of damage, which Mr. Reed gives [See Summary adjoining].

*Italics ours. A subsequent passage makes a very strong point of the impossibility of holding many unprotected window openings with few men, if there is not even the partial protection of metal-covered frames and sash, wire-glass, or similar means of partial defence.—Ed.

Summary of Fireproof Buildings and Fire Damage Record.

The following is a condensed record in this fire of all the fireproof buildings in San Francisco. For convenience they are classified into:

	Number.
Type 1 steel frame, hollow tile floor arches	8
" 2 steel frame, reinforced concrete floor arches	29
" 3 reinforced concrete frame and floor arches	2
" 4 steel frame unenclosed	6
" 5 brick bearing walls, fireproof floor arches	9
Total	54

In all the following accounts of damage, unless otherwise mentioned, the following facts are to be included:

Contents destroyed.
Finish floors, wood, destroyed.
Sleepers, wood, destroyed.
Trim, wood, destroyed.
Back-filling, loose cinders.
Top floor, hanging ceiling structural damage.
Attic, rafters unprotected.
No part habitable after the fire.
Electrical, gas and plumbing system, surface tiling, ornamental iron work and mechanical plant generally wrecked.
Windows, ordinary glass, destroyed.
Sash doors, ordinary glass, destroyed.
Transom, ordinary glass, destroyed.
Skylights, ordinary glass, destroyed.
Window protection, none.
Stairs, slate and metal, structural damage moderate.
Elevators (iron grille) structural damage severe.

The expression "apparent damage" is used in the following account to indicate what is visible to an ordinary observer. It is known that there was injury to steel frames, floor arches, exterior walls, and other structural elements by straining which is not thus apparent. It is quite certain that had there been no fire many of the structures apparently sound would have required extensive repairs.

TYPE I.—STEEL FRAME, HOLLOW TILE FLOOR ARCHES (EIGHT BUILDINGS).

1. CHRONICLE BUILDING (New), 8-16 Kearney St.—Building enclosed, trim not yet begun, lumber on premises, communication open with old Chronicle Building.

Height, 15 stories; 5,600 sq. ft. ground area.
Frame: steel; structurally sound, except as below.
Floor arches: hollow tile, flat arch; structurally sound, except as below.
Column protection: hollow tile; structurally sound, except as below.
Girder protection: hollow tile; structurally sound, except as below.
Beam protection: skewbacks of floor arches; structurally sound.
Partitions: hollow tile; structurally sound.
Exterior fronts: pressed brick; considerable shock damage to pilasters at tenth floor.
Exterior rears: brick; damage slight.

NOTE.—Lower webs of tile arches damaged on lower floors. Buckled columns on southwest corner upper floors, above roof of old Chronicle Bldg. adjoining.

2. CROCKER BUILDING, corner Market and Post Sts. (1891.)

Offices; 10 stories, 10,000 sq. ft. ground area.
Frame: steel, also outside bearing walls; generally sound, structurally, except as below.
Floor arches: hollow tile, flat arch; extensive damage to lower webs.
Column protection: hollow tile; local damage.
Girder protection: hollow tile; local damage.
Beam protection: skewbacks of floor tile; local damage.
Partitions: hollow tile; moderate damage.
Exterior fronts: limestone 1, 2; brick and terra cotta; slight damage.
Exterior rears: brick; apparently sound.

NOTE.—This is not strictly a steel skeleton building, as the exterior are bearing walls. Still the interior framing is of modern steel type with vertical continuity. Light columns top floor. Some failed from poor protection.

3. JAMES FLOOD BUILDING, corner Market and Powell Sts. (1903.)

Offices; 12 stories; 40,000 sq. ft. ground area.
Frame: steel; apparently sound, structurally.
Floor arches: hollow tile, segmental arch, concrete-filled haunches; apparently sound, structurally.
Ceilings: plaster on wire lath; local damage.
Column protection: hollow tile; local damage.
Girder protection: hollow tile; local damage.
Beam protection: ceiling offset; generally sound.
Partitions: hollow tile; local damage.
Exterior fronts: sandstone and brick; local damage.
Exterior rears: brick; local damage.
Finish, floors: cement.

4. MILLS BUILDING, northeast corner Bush and Montgomery Sts. (1892.)

Offices; 10 stories; 21,000 sq. ft. ground area.
Frame: steel; apparently sound, except as below.
Floor arches: hollow tile, flat arch; local wreckage.

Ceilings: lower webs of floor arches; extensive damage on lower floors.
Column protection: hollow tiles; extensive damage on lower floors.
Girder protection: hollow tile; extensive damage on lower floors.
Beam protection: skewbacks of floor arches; extensive damage on lower floors.
Partitions: hollow tile; extensive damage on lower floors.
Exterior fronts: marble 1, 2; brick and terra cotta above; stone spalled at windows.
Exterior rears: brick; brick slight damage.
Exterior court: brick; extensive damage.

NOTE.—Loose back-filling has allowed drop to safes, a number of which went through several floors. Several column failures in basement. Pipes back of column covering contributed to damage of latter.

5. MUTUAL LIFE INSURANCE CO., southeast corner Sansome and California Sts.

Offices; 9 stories; 5,000 sq. ft. ground area.
Frame: steel; apparently sound, structurally.
Floor arches: hollow tile; local damage.
Ceilings: lower webs of floor arches; local damage.
Column protection: hollow tile; local damage.
Girder protection: hollow tile; local damage.
Beam protection: skewbacks of floor arches; local damage.
Partitions: hollow tile; local damage.
Exterior front: stone and brick; spalled.
Exterior rear: brick; generally sound.

NOTE.—Part of upper floors broken through to roof, from failure of frame protection in attic.

6. SPRECKELS DWELLING, corner Clay St. and Van Ness Ave.

Dwelling; 5 stories; mansard; 10,000 sq. ft. ground area.
Frame: none.
Floor arches: hollow tile; explosion damage.
Exterior fronts; sandstone facing; spalled under lintels.

NOTE.—Steel floor beams were carried by exterior and interior brick bearing walls. Efforts were made to blow up this building.

7. SPRING VALLEY WATER CO. BUILDING, southeast corner Geary and Stockton Sts.

Dry Goods 1st and 2d; offices above; 6 stories; 19,000 sq. ft. ground area.
Frame: steel; apparently sound, except as below.
Floor arches: hollow tile, flat arch; apparently sound, except as below.
Column protection: hollow tile; local damage, except as below.
Girder protection: hollow tile; local damage, except as below.
Beam protection: skewbacks floor arches; extensive damages.
Partitions: hollow tile; extensive damage.
Exterior fronts: stone mainly; moderate damage.
Exterior rears; brick; slight damage; except as below.

NOTE.—Southeast corner, rear, wrecked. Probably column failures from heat.

8. UNION TRUST CO., 2 Montgomery St.

Offices; 9 stories; 8,400 sq. ft. ground area.
Frame: steel; apparently sound.
Floor arches: hollow tile, flat arch; frequent ceiling damage, especially lower floors.
Column protection: hollow tile, flat arch; local damage.
Girder protection; hollow tile; slight damage.
Beam protection: skewbacks of flat arches; frequent damage.
Partitions: hollow tile; frequent damage.
Exterior front: granite 1, 2; brick above; granite spalled under lintels.
Exterior rear: brick; apparently sound.

TYPE 2.—STEEL FRAME, REINFORCED CONCRETE FLOOR ARCHES (29 BUILDINGS).

9. AETNA (YOUNG) BUILDING, 101 Market St., corner Spear.

Stove salesrooms and offices; 6 stories; 3,000 sq. ft. ground area.
Frame: steel; apparently sound, structurally.
Floor arches: reinforced concrete (expanded metal); apparently sound, breaks on third floor.
Ceilings: lath suspended; destroyed.
Column protection: hollow 1-in. plaster on expanded metal; superficial damage extensive.
Girder protection: concrete solid; apparently sound.
Beam protection: intermediate concrete beams on suspension strap; apparently sound.
Exterior fronts: stone 1, 2; brick and terra cotta; stone extensively spalled; brick and terra cotta slight damage.
Exterior rears: brick; earthquake damage to coping.
Foundation on piles.

NOTE.—Melted glass found on second floor.

10. ALTAMONT BUILDING, southeast corner Bush and Kearney Sts.

Apartments; 8 stories; 1,500 sq. ft. ground area.
Frame: steel.
Floor arches: reinforced concrete (Roebling B) 12-ft. spans.

NOTE.—This building was dynamited and entirely destroyed.

11. ARONSON BUILDING, northwest corner Mission and Third Sts. (1905-6.)

Clothing and other mercantile; 10 stories; 9,350 sq. ft. ground area.
Frame: steel; apparently sound, except as below.
Floor arches: reinforced concrete; apparently sound, except as below.
Ceilings: open.
Column protection; hollow tile; extensive damage.
Girder protection: concrete solid; apparently sound, except as below.
Beam protection; concrete solid; apparently sound, except as below.
Partitions: hollow tile; extensively wrecked.
Exterior fronts: stone below, brick and terra cotta above; some extensive cracks.
Exterior rears: local damage.

NOTE.—Two basement columns with hollow covering buckled, tiers above sunk one ft., caused by fire. Other basement columns with solid concrete protection no damage. Tiers above failed; columns subsided straight; adjacent floor slabs disturbed, not broken.

12. ATLAS BUILDING, 604 Mission St. (1905.)

Offices; 8 stories; 3,000 sq. ft. ground area.
Frame: steel; sound.
Floor arches; reinforced concrete (expanded metal); sound.
Ceilings: plaster on expanded metal; sound.
Column protection: hollow on expanded metal; sound.
Girder protection: concrete solid; sound.
Beam protection: concrete solid; sound.
Partitions: hollow tile; sound.
Exterior fronts: slight damage.
Exterior rears; brick; slight damage.

NOTE.—Most of this building was left by the fire in a habitable condition.

13. BULLOCK & JONES BUILDING, 108-110 Sutter St.

Several tenants—tailors, men's furnishing, with manufacturing; 8 stories; 4,000 sq. ft. ground area.
Frame: steel; apparently sound, except as below.
Floor arches: reinforced concrete (expanded metal); apparently sound.
Ceilings: open.
Column protection: hollow, plaster on expanded metal; superficial damage, except as below.
Girder protection: concrete solid; apparently sound.
Beam protection: concrete solid; apparently sound.
Exterior fronts; molded terra cotta; extensive damage.
Exterior rears: brick; considerable damage.

NOTE.—Heavy blasting opposite may be responsible for much of exterior damage. A column on third floor has buckled from heat.

14. CALIFORNIA CASKET CO., 941 Mission St. (1905-6.)—Completed except trim. Not yet occupied. A little lumber pile inside.

Height, 7 stories; 10,700 sq. ft. ground area.
Frame: steel; sound.
Floor arches: reinforced stone concrete (Roebling B-2); sound.
Spans: 5 ft. 10 ins.
Ceilings: open.
Column protection: concrete solid; sound.
Girder protection: concrete solid. 20-in. girders; sound.
Beam protection: concrete solid, 15-in. beams; sound.
Partitions: few plaster and cement on wire lath, metal straps; sound.
Exterior fronts: sandstone; sound.
Exterior rears: brick; sound.

NOTE.—This building is conspicuous for its slight apparent damage.

15. CASA CALWA BUILDING, 174-6 Townsend St.

Wine storage; 2 stories; 10,000 sq. ft. ground area.
Frame: steel; sound, except as below.
Floor arches; reinforced concrete; sound, except as below.
Beams: intermediate reinforced concrete; sound, except as below.
Exterior walls: brick; sound, except as below.

NOTE.—Dynamiting adjoining, blew out wall. Practically all damage limited to this.

16. FERRY BUILDING, foot Market St.

Oakland Ferry passenger and baggage rooms, exhibition rooms of minerals and products; offices; main building, 3 stories; 112,000 sq. ft. ground area; tower, 235 ft. high.
Frame: steel; apparently sound.
Floor arches: reinforced concrete (expanded metal); sound.
Exterior: sandstone facing; sound.

NOTE.—This building was not reached by the fire. Part of stone exterior of tower fell on roof and broke through to second story. Earthquake damage frame of tower.

17. FAIRMOUNT HOTEL, California and Mason Sts.—Nearly completed, including trim; not yet occupied; lumber and material in quantity.

Height, 6 stories; 66,000 sq. ft. ground area.
Frame: steel; generally sound, some serious failures in upper floors.
Floor arches: reinforced concrete (expanded metal); generally sound, some serious failures in upper floors.
Ceilings: hollow, plaster on wire lath; superficial damage.
Column protection: concrete, solid, except as below; local damage.
Girder protection: part solid concrete; part hollow finish plaster on expanded metal; local damage.
Beam protection: concrete solid; apparently sound.
Partitions: part hollow tile, part metal lath; extensive damage.
Exterior fronts: granite below, hollow tile above; spallings under lintels locally.
Exterior courts: brick; moderate damage.

NOTE.—Column protection omitted in hollow studded interior spaces, and collapse occurred in such places.

18. FOLGER WAREHOUSE, rear of lot, corner Spear and Folsom Sts.

Height, 4 stories; 2,000 sq. ft. ground area.
Brick walls: reinforced concrete floor arches.

NOTE.—The interior of this building was not reached by the fire.

19. GRANT BUILDING, southeast corner Market and Seventh Sts. (1903.)

Market Street Bank; offices; 8 stories; 5,500 sq. ft. ground area.
Frame: steel; sound, structurally.
Floor arches: reinforced cinder concrete (Roebling B-1); sound, structurally.
Spans: 6 and 7 ft.
Ceilings: first floor open, rest wire lath; sound, structurally.
Column protection: hollow, on wire lath, 1st, 3d; hollow tile above; sound, structurally.
Girder protection: 15-in. solid concrete; sound, structurally.
Beam protection: concrete solid; sound, structurally.
Partitions: hollow tile 4th; local damage.
Exterior fronts: brick; local damage.
Exterior rears: brick; local damage.

20. HAYWARD (KOHL) BUILDING, northeast corner California and Montgomery Sts.

Offices; 11 stories; 9,000 sq. ft. ground area.
Frame: steel; sound.
Floor arches: reinforced concrete on expanded metal; sound.
Ceilings: hollow, plaster on expanded metal; sound.
Column protection: hollow, plaster on expanded metal; sound.
Girder protection: concrete, solid; sound.
Beam protection: concrete, solid; sound.
Partitions: hollow tile; sound.
Exterior fronts: sandstone 1, 2; brick above; sound.
Exterior rears: brick; sound.

NOTE.—All wooden trim, including window casings, was metal covered (Berger system). Damage to this building confined to first, second, third and fourth floors and roof house. All the remainder fully habitable, and contents uninjured.

21.—HALL OF JUSTICE, corner Kearney and Washington Sts.

Steel frame; reinforced concrete floor arches (expanded metal). Partly wrecked by shock and subsequently damaged by exposure to fire, which caused fall of the cupola.

22. HARRON, RICKARD & McKONE, south side Mission St., between First and Fremont.—Machinery and similar stock, printing and envelope factory, etc.

Height, 4 stories and mansard; 20,000 sq. ft. ground area; largest of 5 sections.
Frame: steel; apparently sound, structurally.
Floor arches: reinforced concrete; apparently sound, structurally.
Ceilings: plaster on expanded metal; all down.
Column protection: concrete, solid; apparently sound, structurally.
Girder protection; concrete, solid; apparently sound, structurally.
Beam protection: concrete, solid; apparently sound, structurally.
Exterior fronts: stone; moderate spalling.
Exterior rears: brick; local damage.

NOTE.—Exterior walls were bearing walls. Mansard was destroyed by earthquake. Western section was wrecked by earthquake and dynamite.

23. HOTEL ALEXANDER, 356 Geary St., between Powell and Mason.—Hotel nearly completed.

Height, 11 stories; 4,700 sq. ft. ground area.
Frame: steel; apparently sound, structurally.
Floor arches: reinforced concrete; apparently sound, structurally.
Ceilings: hollow, plaster on metal lath; local damage.
Column protection: hollow tile; local damage.
Girder protection: concrete, solid; apparently sound, structurally.
Beam protection: concrete, solid; apparently sound, structurally.
Partitions: hollow tile; locally wrecked.
Exterior front; sandstone; superficial damage.

24. HOTEL HAMILTON, 125 Ellis St.

Hotel; 12 stories; 3,100 sq. ft. ground area.
Frame: steel; apparently sound, structurally.
Floor arches: reinforced concrete (Collins); considerable damage.
Ceilings: hollow, plaster on metal lath; considerable damage.
Column protection: hollow tile; damage.
Girder protection: concrete, solid; damage.
Beam protection: concrete, solid; damage.
Partitions: hollow tile; damage.
Exterior: brick; local damage.

25. KAMM BUILDING, 715 Market St. (1905.)

Wall paper warehouse, 1st and basement; 7 stories; 9,000 sq. ft. ground area.
Frame: steel; extensive damage.
Floor arches: reinforced rock concrete (Roebling B-2); extensive damage.
Spans: 5½ ft.
Ceilings: hollow, plaster on wire lath; extensive damage.
Column protection: part plaster metal lath, part solid; extensive damage.
Girder protection: concrete, solid, 18-in. girders; extensive damage.
Beam protection: concrete, solid, 12-in. beams; extensive damage.
Partitions: plaster on wire lath, iron studs; extensive damage.
Exterior fronts: sandstone; damage.
Exterior rears: brick; extensive damage.

NOTE.—Column failures occurred in basement from protracted heat of burning wall paper stock against hollow protected columns. The entire rear section was wrecked, interior and exterior. The column tiers went down straight 8 or 10 ft. in places, retaining their protective covering. A large part of exterior walls was distorted or thrown out. The front section experienced slight structural damage.

26. MERCHANTS' EXCHANGE, 433 California St. (1903.)

Offices; 13 stories; 25,000 sq. ft. ground area.
Frame: steel; apparently sound, structurally.
Floor arches: reinforced cinder concrete (Roebling B-1); apparently sound, structurally.
Spans: 7 ft.
Ceilings: hollow, plaster and cement on wire lath; superficial damage.
Column protection: hollow, plaster and cement on wire lath; apparently sound.
Girder protection: concrete, solid; apparently sound.
Beam protection: concrete, solid; apparently sound.

Partitions: plaster and cement on wire lath on iron studs, some 2 ins. hollow and some 2 ins. solid; extensively wrecked.
Exterior fronts: stone and brick; limited damage.
Exterior rears: brick; limited damage.
Exterior court: brick; extensive damage.

27. MONADNOCK BUILDING, east side Annie, between Market and Stevenson Sts.

Offices; 10 stories; 18,000 sq. ft. ground area.
Frame: steel; apparently sound, except as below.
Floor arches: reinforced concrete; generally sound.
Ceilings: plaster on wire lath; extensive wreckage, locally.
Column protection: hollow, plaster on expanded metal; generally sound, except as below.
Girder protection: concrete, solid; apparently sound, except as below.
Beam protection: concrete, solid; apparently sound, except as below.
Partitions: plaster on wire lath; apparently sound, except as below.
Exterior fronts; sandstone 1st and 2d, brick above; considerable apparent damage.
Exterior courts: brick; slight apparent damage.

NOTE.—The original plan of this building was for wooden beams, floors of mill type, on steel girders. Altered to reinforced concrete beams carried by steel girders with reinforced concrete floor arches. The building was being extended west and south, and part of those side was open. Some damage was done by dynamite in adjoining building. A column has failed in basement, and let down surrounding panels above.

28. MUTUAL SAVINGS INSTITUTION, 708-12 Market St. (1902.)

Offices; 12 stories; 5,000 sq. ft. ground area.
Frame: steel; apparently sound, structurally.
Floor arches; reinforced stone concrete (Roebling B-3); apparently sound, structurally.
Spans: 7 ft.
Ceilings: hollow, plaster on wire lath except basement; generally sound.
Column protection: hollow, plaster on wire lath except basement; generally sound.
Girder protection; solid concrete; generally sound.
Beam protection: solid concrete; generally sound.
Partitions: hollow and solid on wire lath, iron studs; considerable damage.
Exterior fronts: sandstone 1-2, brick above, tile mansard; stone spalled, brick and tile considerable damage.
Exterior rears: brick; slight damage.
Cement finish floors, 1st and 2d.

29. PACIFIC STATES TELEGRAPH & TELEPHONE CO., 427 Bush St. (1905.)—Not in operation, equipment nearly completed.

Telephone Exchange ("Main" station); 8 stories; 2,500 sq. ft. ground area.
Frame: steel; apparently sound, except as below.
Floor arches: reinforced stone concrete (Roebling B-1); sound.
Spans: 7 to 8 ft.
Ceilings: open in basement, plaster on wire lath above; sound, except as below.
Column protection: concrete, solid; sound.
Girder protection; concrete, solid; sound.
Beam protection; concrete, solid, 15-in. beams: sound, except as below.
Partitions: cement and plaster on wire lath on metal studs; moderate damage.
Exterior fronts; brick; generally sound.
Exterior rears: brick; generally sound.

NOTE.—Floor arch broken through, seventh floor. Intermediate roof beams of reinforced concrete, one has failed, leaving hole in roof. Hanging ceiling on the eighth under roof, plaster on wire lath, all down. Window protection, east side and rear, wire glass in metal covered swinging sash, hinges screwed to metal-covered wood jambs. Inside sliding tin-covered wood shutters, slide back of wall furring, consisting of plaster on cement on wire lath, iron furring frame. Front windows plate glass, metal-covered sash, outside rolling steel shutters. The tin-covered shutters as a general rule have bulged away from wall on account of interior fire. Wire glass intact, except at two points. Rolling steel shutters uninjured, glass behind them destroyed and in places melted.

30. PACIFIC STATES TEL. & TEL. CO., 40 West Mission St. (1905.)

South Mission Exchange; 3 stories; 7,200 sq. ft. ground area.
Frame: steel; apparently sound, structurally.
Floor arches: reinforced gravel and cinder concrete (Roebling B-1); apparently sound, structurally.
Spans: 8 ft. 2 ins.
Column protection: concrete, solid; apparently sound, structurally.
Girder protection: concrete, solid; apparently sound, structurally.
Beam protection: concrete, solid, 15-in. beams: apparently sound, structurally.
Ceilings: open basement, rest wire lath; apparently sound, structurally.
Partitions: hollow, wire lath, metal studs; generally sound.
Exterior fronts: brick; sound, except as below.
Exterior rears: brick; sound, except as below.
Finish floor: cement.

NOTE.—West wall, upper part, thrown out by earthquake, let in fire, which burnt out third floor. First and second floors habitable and contents preserved. Building was deserted during fire.

31. PACIFIC STATES TEL. & TEL. CO., west side Hyde, between Bush and Sutter Sts. (1905.)

Telephone Exchange ("East" station); 3 stories; 5,750 sq. ft. ground area.
Frame: steel; sound, structurally.
Floor arches: reinforced concrete (Roebling); apparently sound.
Exterior walls: brick; apparently sound.

NOTE.—This building was in a frame dwelling district. Front spandrel beam sagged.

32. POST OFFICE, Mission, between Sixth and Seventh Sts.

General Post Office; 3 stories; 68,000 sq. ft. ground area.
Frame: steel; sound.
Floor arches: reinforced concrete, cinder, expanded metal; sound.
Ceilings: Hollow, plaster on expanded metal; sound, except in court room, where it is down.
Column protection: 4-in. concrete and brick solid.
Partitions: Hollow tile, substantial; earthquake damage mainly.
Exterior front: granite, independent; earthquake damage only conspicuous at southwest corner.

NOTE.—This building was not injured by the fire except slightly to the exterior, the court room and two rooms on third floor north corner, burnt out.

33. RIALTO BUILDING, southwest corner Mission and New Montgomery Sts.

Offices; 8 stories; 16,000 sq. ft. ground area.
Frame: steel; extensive local damage.
Floor arches: reinforced concrete (expanded metal); local damage.
Ceilings: hollow, plaster on wire lath; local damage.
Column protection: hollow, plaster on wire lath; local damage.
Girder protection: concrete, solid; local damage.
Beam protection: concrete, solid; local damage.
Partitions: hollow tile; local damage.
Exterior fronts: pressed brick; pilasters cracked.
Exterior rears: brick; local damage.

NOTE.—Column failures in basement, two in northwest corner, one in northeast corner. Cause unknown. Column tiers above subsided vertically with extensive wreckage of adjacent floors. This building was in the region of severe earthquake effect and was also a victim of attempted dynamiting operations.

34. SHREVE BUILDING, northwest corner Post and Grant Sts. (1905.)

Silverware and jewelry 1st and 2d, offices above; 12 stories; 9,000 sq. ft. ground area.
Frame: steel; generally sound, structurally.
Floor arches: reinforced stone concrete (Roebling B-1); generally sound, structurally.
Spans: 5½ ft.
Ceilings: hollow, plaster on wire lath; generally sound, structurally.
Column protection: concrete, solid, B, 1st and 2d, tile above; generally sound, structurally.
Girder protection: concrete, solid, 15-in. and 18-in. girders; generally sound structurally.
Beam protection: concrete, solid, 12-in. beams; generally sound, structurally.
Partitions: hollow tile, 4 ins.; extensive damage.
Exterior fronts: limestone; extensive spalling north.
Exterior rears: brick; apparently sound.
Part of finish floors: cement or tile.

35. SPRECKELS (CALL) BUILDING, southwest corner Market and Third Sts.

Offices and newspaper publishing; 16 stories; with 5-story dome; 310 ft. high, with annex on west, 5 stories; 5,625 sq. ft. ground area; 75 × 75 ft.
Frame: steel; apparently sound, structurally.
Floor arches; reinforced concrete; apparently sound, structurally.
Ceiling: plaster on wire lath; local damage.
Column protection: hollow tile; local damage.
Girder protection; concrete, solid; local damage.
Beam protection: concrete, solid; local damage.
Partitions: hollow tile; local damage.
Exterior fronts: stone faced; hollow tile mansard; damage at windows.

NOTE.—Foundations on platform of steel beams and concrete 4½ ft. thick extending beyond house line. Special plan of bracing very useful in preventing damage from shock.

36. ST. FRANCIS, west side Union Square.

Hotel; 12 stories; 22,000 sq. ft. ground area.
Frame: steel; generally sound, structurally.
Floor arches: reinforced cinder concrete (Roebling); generally sound; structurally.
Spans: 6 and 7 ft.
Ceilings: hollow, plaster on wire lath; generally sound.
Column protection: concrete, solid, 1st; tile above; generally sound.
Girders—depth: 18 to 20 ins.; generally sound.
Girder protection: part solid concrete; part ornamental plaster on wire lath; generally sound.
Beams: Concrete, solid, 10 to 12-in. beams; apparently sound.
Partitions: hollow tile, 4 ins.; extensive damage locally.
Exterior front: stone below, brick above; apparently sound.
Exterior rear: brick; apparently sound.
Exterior court: brick; extensive damage.

NOTE.—Some rooms were left partly habitable. Some column failures where protection was poor.

37. WELLS FARGO BUILDING, corner Mission and Second Sts.

Express offices; 6 stories; 19,000 sq. ft. ground area.
Frame: steel; generally sound, structurally.
Floor arches; reinforced concrete (Ransome); generally sound, structurally.
Ceilings: hollow, wire lath; generally sound, structurally.
Column protection: concrete; generally sound, structurally.
Girder protection: concrete; generally sound, structurally.
Beam protection: concrete; generally sound, structurally.
Partitions: tile; local damage.
Exterior fronts: granite 1st and 2d, brick above; granite much spalled.
Exterior rears: none.

NOTE.—Earthquake cracks in pilasters.

TYPE 3.—REINFORCED CONCRETE FRAME AND FLOOR ARCHES (TWO BUILDINGS).

38. ACADEMY OF SCIENCES, 819 Market St., rear of lot. (1886.)

Height, 6 stories; 7,500 sq. ft. ground area.
Exterior walls: brick; extensive damage.
Columns: cast-iron, concrete filled; apparently sound, structurally.
Girders and beams: reinforced concrete (Ransome); apparently sound, structurally.
Floor arches: reinforced concrete (Ransome); apparently sound, structurally.

NOTE.—Extensive interior wreckage, partly by dynamite. Communication by 2-story portion with 6-story front building of ordinary construction.

39. BEKINS VAN & STORAGE CO., southwest corner Eighth and Tehama Sts.

To be storage; in course of construction; 2 of 6 stories completed; 6,000 sq. ft. ground area; material on premises.
Exterior walls: brick; extensive damage.
Columns: reinforced concrete (Kahn system); superficial damage.
Girders and beams: reinforced concrete (Kahn system); superficial damage.
Floor arches: reinforced concrete (Kahn system); superficial damage.

TYPE 4.—STEEL FRAME, UNFINISHED (SIX BUILDINGS).

40. BUTLER BUILDING.

To be occupied by Newman & Levison, dry goods; building unfinished; steel frame completed; 9 stories; 19,000 sq. ft. ground area; floor arches in to 2d story; exterior walls completed to 4th story.
Frame: steel; apparently sound, except as below.
Floor arches: reinforced concrete (Roebling); apparently sound, except as below.
Exterior fronts: stone and brick; apparently sound, except as below.
Exterior rears: brick; apparently sound, except as below.

NOTE.—Part of exterior walls thrown out by shock and fire. Slight damage to frame locally.

41. UNION LEAGUE BUILDING, Geary St., north side, between Stockton and Grant Sts.

Height, 16 stories; 4,000 sq. ft. ground area.

NOTE.—Frame, steel; completed; apparently sound, except a few beams second floor front slightly sagged. No floors nor side walls yet begun. There was a small quantity of lumber on the first floor.

42. MARSTON BUILDING, corner Kearney St. and Hardie Pl.

Height, 8 stories; 1,200 sq. ft. ground area.
Frame: steel, complete; apparently sound.
Floor arches and intermediate beams: reinforced concrete; apparently sound.
Column protection: concrete, solid; apparently sound.
Girders: concrete, solid; apparently sound.
Beams: concrete, solid; apparently sound.
Exterior: brick complete to 7th story; extensive damage from shock.

NOTE.—There was a quantity of lumber and material on the premises. The upper parts of the unfinished side walls were thrown out and some damage was done to corners of brick-work from the shock of the earthquake or neighboring blasts.

43. NEW BUILDING, north side Mission, between First and Second Sts.

Frame: steel up two stories; sound, except a few beams sagged in front.

NOTE.—No walls nor floor arches yet erected. A small quantity of scaffolding was on the premises.

44. RUEF BUILDING, corner Pacific St. and Montgomery Ave.

To be apartments; 7 stories; 2,000 sq. ft. ground area.
Frame: steel, very light; apparently sound.

NOTE.—Frame completed. Floor arches part in. Side walls not in. Some lumber and material were on the premises.

45. ST. FRANCIS HOTEL ADDITION, Union Square. (1906.) Adjoins hotel on the north. To be 12 stories.

Frame: steel up 10 stories; apparently sound.

NOTE.—No frame protection. Side walls and floor arches not yet in. A quantity of lumber was on the premises. Open communications with the hotel.

TYPE 5.—BRICK BEARING WALLS—FIREPROOF FLOOR ARCHES (ELEVEN BUILDINGS).

46. APPRAISERS' WAREHOUSE, Sansome St., between Washington and Jackson Sts.

U. S. Custom House, etc.; 3 stories; 25,000 sq. ft. ground area.
Brick walls, slate roof, brick arched floors on iron beams 3 to 5 ft. spans. Cast-iron columns unprotected except where in partitions. Fire did not get into the interior of this building, consequently there was no test of its construction.

47. HOBART BUILDING, 532-8 Market St.

Postal Telegraph Co., offices and operating departments; 6 stories; 8,000 sq. ft. ground area.
Bearing walls: brick; apparently sound.
Floor arches; concrete not reinforced; generally sound, except 1st floor partly out.
Spans: 4 ft.
Column protection: cast-iron, covered; no columns above first; generally sound, except 1st floor partly out.
Girder protection: no girders above first, on first unprotected; some sagged in basement.
Beam protection: none on lower flanges; some sagged in basement.

Ceilings: wire lath and plaster under beams; generally sound.
Exterior front: brick, with granite columns first floor; brick, local damage; granite columns, some destroyed by heat.

NOTE.—The roof of this building was wrecked.

48. CHRONICLE BUILDING (Old), 642-650 Market St. (1890).—Newspaper printing and publishing; 10 stories, 7,000 sq. ft. ground area. Eastern section of this building was apparently structurally sound. Western section collapsed from the roof down. This is known to have occurred after 12 o'clock Wednesday. There was a frame clock tower on the roof. There was probably a collapse of columns from heat.

Bearing walls: brick.
Floor arches: hollow tile.
Columns, protection: cast iron, tile covered.
Girders, protection: iron, not covered.
Beams, protection, iron, flanges exposed.
Partitions: hollow tile.
Exterior fronts, brick.
Exterior rear, brick.

49. SLOANE BUILDING, 114-124 Post St.—Carpets and furniture; 7 stories, 14,000 sq. ft. ground area.

Bearing walls: brick; apparently sound, exception below.
Girders and beams: steel; apparently sound, exception below.
Floor arches: reinforced concrete; apparently sound, exception below.
Ceilings: open; apparently sound, exception below.
Columns, protection: cast iron; plaster on wire lath; apparently sound, exception below.
Girder protection: concrete, solid; apparently sound, exception below.
Beam protection: concrete, solid; apparently sound, exception below.
Exterior front: brick and terra cotta; apparently sound, exception below.
Exterior rears: brick; apparently sound.

Note—This building had several column failures in the basement, apparently from fire. The column tiers above subsided vertically about 1 ft. The adjacent floor bays were distorted, but not broken, and subsequently were knocked out.

50. HIBERNIA BANK, northwest corner McAllister and Jones Sts. Height: 2 story, 17,000 sq. ft. ground area. Stone exterior front with heavy architectural features. Brick rear. Interior framing steel, with floor arches of both brick and concrete. Composite roof, iron and wood. Structural injury was confined largely to the roof, and there was heavy spalling of exterior stone under lintels of windows on east side.

51. MERCANTILE TRUST CO., 430 California St.—Bank, 3 stories, 5,500 sq. ft. ground area. Stone front, brick side and rear walls. Interior frame steel. Floor arches reinforced concrete. Roof arched, steel frame and glass. Structural injury was largely confined to roof.

52. SECURITY SAVINGS BANK, 314 Montgomery St.—Bank, 2 story, 2,400 sq. ft. ground area. Stone front. Brick side and rear walls. Interior frame steel. Floor arches fireproof. Light steel frame roof. Structural injury extensive, mainly caused by falling wall of building on the south.

53. CITY HALL, Larkin and McAllister Sts.—Exterior stone and brick, with columns of cast iron filled with concrete, all grouped around a skeleton steel dome. Floors steel beams, corrugated iron floor arches. This building was wrecked by the shock and subsequently gutted by exposure fire.

54. U. S. MINT.—3 stories, 20,000 sq. ft. ground area. Granite faced brick walls, flat roof, brick arch floors on iron beams, 3 to 5-ft. spans. Cast iron columns, unprotected except by partitions. Fire did not get a footing in the interior of this building; therefore there was no test of its construction.

GLOBE MILLS.—This was a building with concrete exterior walls, and concrete floor arches on unprotected steel girders and iron columns. The building was structurally wrecked. Not included in fireproof class on account of non-protection of structural metal.

NATOMA ST., northwest corner of First St.—This was a building with brick bearing walls on protected cast iron columns, steel girders and reinforced concrete floors. Front bays of all floors also all of upper floors wrecked. Not included in fireproof class on account of non-protection of structural metal.

GENERAL RESULTS.

The nearly complete structural immunity of the modern "fireproof" building under conflagration conditions is considered established. The moral value of the survival of such buildings, even if gutted, is appreciable. The salvage is less important. Experience at Baltimore showed a loss averaging over 60% [Eng. News, Feb. 9, 1905, p. 136] on the total value of the building.

The illusory nature of this salvage is due to the fact that the most expensive part of the usual steel frame building is not the steel whose original cost in Baltimore averaged 13% of the total original cost, nor the floor arches whose original cost averaged 5% of the total, nor even the brick exterior walls, whose original cost averaged there about 15% of the total; but the principal values, viz.: 67%, are in other items—such as ornamental stone, decoration, finish, trim, partitions, glass, interior light metal work, tiling and marble, plumbing, wiring and fixtures, together with a large item in mechanical plant, all of which items are apt to be total losses. It will also be noticed from these figures that, inasmuch as the first cost of the floor arches is only 5% of the total value of the building, it makes only 2% difference on the final loss whether, as in the case of the tile arch, 60% is ruined and needs replacing, or, as in the case of the reinforced concrete arch, there may be damage of not over 10%. So long as the fireproofing protects the integrity of the steel frame there is a gain of the 15% represented in the frame itself, though even that is not likely to be of any advantage to the Underwriter, except for a trifling percentage due to the saving of time in rebuilding.

PROBLEM NARROWED.—There is, however, a significance attaching to the fact that a type of construction may have developed which will take care of itself structurally in a conflagration, in that the problem of securing nearly complete immunity for these buildings is reduced to the one matter of protection of windows and other wall openings, the problem being thus narrowed and defined. The hoped-for character of the fireproof building, as a conflagration break, has been considerably discredited in two great conflagrations; but it has also been shown that the American tall building is, in conflagrations, the innocent victim and not the aggressor. It is not likely that even San Francisco will be able to resist the demand for permission on the part of owners to reconstruct with wooden beam floors, at least to moderate heights, and certainly no American city in this generation is likely to succeed in enacting a law prohibiting the use of wooden structural material, at least in buildings up to four stories in height. Therefore, for years to come, American cities will consist of tall buildings of fireproof construction, surrounded by non-fireproof buildings ready under unfavorable combinations of circumstances, to develop conflagrations limited only by superior extinguishing methods and by an increase in precautions relating to the occurrence of fires. If such conflagrations are not to involve the valuable fireproofs, the latter must develop a proper system of window protection.

WINDOW PROTECTION.

Metal-Covered Trim.—The Kohl Bldg. afforded the first conflagration experience with metal-covered interior and window trim. The windows were plate glass, and partition glazing ordinary glass. The building made an excellent showing.

Caution must be exercised in drawing broad conclusions from this case. The fact that the majority of the plate-glass windows are not even cracked shows that the upper floors did not receive any severe shock. The building was not deserted during the fire. Furthermore, the three lower floors are extensively burned out, the wood having ignited under its metal sheathing, showing that when the glass of windows breaks and fire takes hold of the contents of the room the heat soon penetrates the thin metal sheathing of the trim. Still, there is a definite, though small, advantage in this detail of protection. * * * There are places, especially in a region of fireproof buildings, where the prevalent cause of ignition is not the general drift so much as sparks and brands which lodge on window sills and ignite the sash frames. * * * There will be many places where the temperatures are just on the margin short of the point where plate-glass will break, but above the point where exposed and painted wood will ignite. In these cases the fact that the trim is metal-covered may turn the scale.

Wire-Glass.—The Western Electric Co. building owed its successful defence in part to its wire-glass windows. The radiant heat passed through the glass and ignited the woodwork in the building, but "the retardant though not positively resistant effect of the wire-glass and metal-frame window protection gave the small force of two or three men a chance to take care of 50 or 60 windows and extinguish ignition fires in detail." In the Bush St. and Mission St. telephone exchanges, wire-glass also showed excellent resistance.

Fire Shutters.—As no building was completely fitted with shutters, no test of their protecting power was afforded.

Several walls were standing, however, with tin-covered shutters still hanging at their window openings, apparently sound. Old-fashioned inside folding iron shutters deserve credit in several cases. The two lower floors of the Mint were protected with them, and, though the glass in the sash was destroyed, the shutters appear to have been uninjured. * * *

Rolling steel shutters in the Bush St. exchange, where the most destructive fire was internal, remained uninjured, although the window glass was in places melted into a mass on the window sill (ordinary glass).

The report concludes on window protection:

The results point to the importance of sub-standard as well as standard window protection, as an encouragement to men to remain in and make an effort to save the threatened building. The number of city buildings in which, for reasons of economy and convenience, it will be possible to secure sub-standard front window protection will probably be large compared to the number of those in which owners can be induced to install protection of the highest standard.

The plan of a double line of defence has great merit. Two or more semi-pervious screens, one behind the other, may be better than a single nearly impervious screen.

FLOORS.

Reinforced-Concrete Floor Arches.—The excellent behavior of this type of floor is remarked on. Over 30 fireproof buildings of good height had this type of floor, and 15 of them carried mercantile stocks, while most of them were exposed to maximum exterior conditions. A variety of styles and designs was represented, and the results showed about equal ability to withstand the test.

The type of material in floor arches was cinder concrete in building erected previous to 1904; but on account of the scarcity of cinders due to the prevalence of the use of fuel oil later work used stone concrete. It is doubtful whether the reinforced concrete floor arches which have been through the shock and fire have retained their full strength. In this particular the tile arches may have an advantage.

COLUMN PROTECTION AND COLUMN FAILURES.

The tile column covering used in San Francisco was about the same as that represented in the Baltimore fire. Concrete column covering, both air-space and solid, were also represented by numerous examples in the more recent conflagration.

Air space coverings of plaster or cement on metal webbing did fairly well, though several authenticated cases of column failure occurred with such covering. The best results, however, were shown by solid concrete column covering without air space, the concrete being reinforced by metal webbing. It is probable that the air space idea will be in less repute in all future efforts to armor structural steel. It has been shown to be largely fallacious in practice. The results in the Bush Street Telephone Exchange may be considered fairly decisive as to solid concrete column protection. The temperatures in this building were not only extreme, but were also protracted. The very excellence of the window protection prevented the air from entering the building at the sides, while the break in the roof afforded just sufficient draft to generate intense and long-continued heat. The large quantity of combustible insulation and other material provided ample fuel, and the writer found numerous cases of melted glass. Nearly all the light iron framework of switchboard apparatus was found collapsed into a heap and even a quantity of wire nails was found welded into a mass; yet the column protection appeared to be perfect. The bracing effect of the solid concrete encasing the steel column is doubtless an important factor, and it is probable that with such reinforcement the steel might even attain a softening temperature without deflection.

On the column failures themselves, the report states that the large number of such failures points to the necessity of working out a standard for column protection. Reducing the failures to percentage figure, it is found that the buckled (crushed) steel columns in fireproof buildings gutted by the fire are about one-half of one per cent. of the total number of steel columns in these buildings. The fact that a large proportion of the failures occurred in basements is taken to indicate that the slower combustion here, due to the damping effect of debris, may produce more protracted high temperature. It is suggested that extra heavy column protection should be provided in basements, even at a sacrifice of space.

A paragraph relating to the effect of the fire on six steel frames of unfinished buildings may be quoted:

Four of these steel frames were completed and one was up two stories. In four of the cases the floor arches were not yet in. All the frames appeared to be uninjured, except that an occasional beam near the street grade has sagged and will have to be replaced. All were in the path of the maximum conflagration sweep; but they appear to have been affected only by the wooden material, scaffolding, etc., on their own premises, i. e., where close to such material there was a local effect; but the frames seem to have been indifferent to the exposure at any considerable distance. It is probably the case that, in the long-range blast, the temperatures, though above the point of wood ignition, are below the softening temperature of iron and steel, except at very close quarters; so that the general effects are confined to expansion; and conflagration experience has pretty well settled the fact that a steel frame can undergo a large and uneven range of expansion and subsequent contraction without serious injury to its own members or their connections, provided the temperature is short of the softening point. These frames also had the advantage of being largely free from load.

Finally, the following lessons and conclusions terminate the report:

The importance of both front as well as rear and side window protection, fire-resistant if possible, but at any rate fire-retardant.
The importance of encouraging individual protection by occupants of buildings.
The importance of fire-resisting roofs, roof structures and of well protected skylights.
The importance of ample water supply and pressure.
The importance to the fire department of a large reserve of hose, and of apparatus of longer range and heavier caliber. The latter need not be limited by the same conditions of quick response to alarms as ordinary apparatus.
Restriction upon the use of explosives in conflagrations.
In hollow tile for fireproof building the importance of improved sections giving greater strength to lower webs.
The importance in partitions of a better bracing of tile, and the importance of fire-retardant transoms as well as doors.
The importance of better protection to the steel frame in roof attics.
The importance of good bricklaying and mortar with cement instead of lime.
The encouraging possibilities of reinforced concrete, and the importance of good engineering in its installation.
The necessity of adopting standards for column protection.
It has been considered a reasonable assumption that a conflagration destroying the business part of a city would still probably be checked in the brick dwelling quarter. The experience of San Francisco, whose dwelling district was almost entirely frame, cannot be considered a ground for changing this view.

A SAND FILTER FOR THE HOME.*

By Robert Fletcher.†

The writer has had in successful operation during the past several years a series of small sand filters made and operated according to the principles governing the action of large sand filters of city water supplies. During periods when the reservoir-water supplied to the town was turbid or distinctly obnoxious to taste or smell—from presence of algæ or other organisms therein—the water passing through these filters was perfectly potable, without taste or smell and nearly free from color. In the earlier experiments the filter cases were made of galvanized iron, but the interior of these became rusty after a few years, and the rust finally caused leaks. The form to be described has an imperishable encasement and possesses the following advantages: All the parts and material are easily procured, comparatively inexpensive, will not rust or decay, and will remain clean. The operation is as simple as possible, without valves or mechanism, or use of any patented devices. The filter will continue in use indefinitely, without renewal of parts, and with far less care and attention than is required by any other apparatus of the household economy. It can be made by any man who has acquired ordinary facility in doing small jobs about his house, or by competent hired help, in a few hours. For the writer a handy man, having the materials all ready, has repeatedly set up such a filter in three hours. The parts in detail or the combination as a whole are not patentable.

The drawing shows two styles, A and B. Style A is intended for service when the water supply is handled by pail from a well, cistern or running stream. The filter must then be fed from a superimposed tank, which must be filled by hand as often as required. Style B is adapted to situations where the water is supplied through an aqueduct pipe, so that the filter may be fed through a regulating valve and short length of small pipe.

HOW TO MAKE THE FILTER.

Provide a suitable solid and strong support, impervious to water, near a sink or drain pipe, so that there will be convenient escape for the overflow. The weight to be supported is about 375 lbs. for style B and 450 lbs. for style A (see the drawing). There should be about 7 ft. height of clear space above the support for style A and 5 to 5½ ft. for style B. If it is not easy to get a slab of slate or soapstone, or to make a base of brick (with a cement coat) and mortar, a slab of mortar or cement and sand may be made.

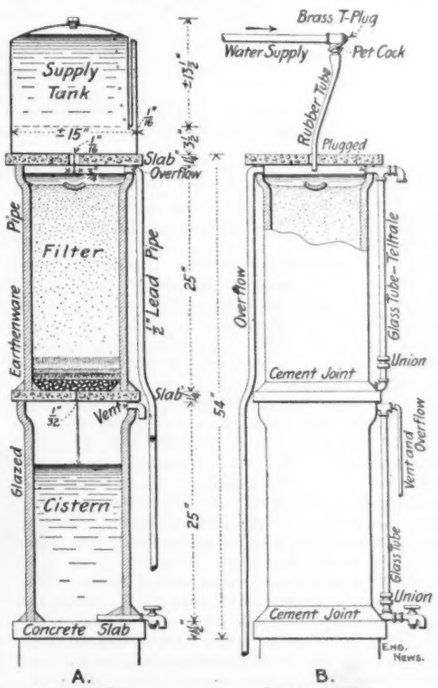
(1) Make a circular mold or form about 16 ins. in diameter, by bending a piece of sheet iron (2 ins. wide), or a piece of barrel hoop, into a circular shape. Place this on some flat, smooth surface, as a floor or bench (preferably on a sheet of metal, which will not absorb water); take about seven quarts of clean sand or fine stuff from a stone-crusher and about four quarts of good Portland cement and *mix thoroughly* in dry state; then gradually add water and work with a mason's trowel (a garden trowel will serve tolerably well) to a consistency of fairly stiff mortar; fill by degrees into the mold and gently tamp with a stick while filling, until the form is full and water stands on the upper surface, after smoothing with the trowel. The gradual filling and tamping are necessary to exclude air bubbles and make a dense water-tight slab. Let this stand about two days—until hard enough to handle.

(2) At the same time and in a similar manner make the intermediate slab and the upper or covering slab shown in the drawing, with the following differences: thickness need be only about 1¼ ins.; in the center of the intermediate slab a hole must be left 1/32-in. in diameter, to make which insert a wire, No. 21 Birmingham wire gage, and remove within a few hours, before the cement is set hard around it. (Draw it upwards gently with a twisting motion so as not to enlarge the hole on the under side and yet leave the passage a trifle larger on the upper side of the slab and with a smooth interior.) In the upper slab make a hole about ¾-in. in diameter by placing a wooden plug in the center during the molding process.

(3) TO PLACE THE LOWER SECTION WHICH SERVES AS A CISTERN.—Having at hand the piece of half-inch brass pipe for the outlet tightly screwed into the faucet, roughen the surface of the pipe by nicking with a file or cold chisel; prepare enough cement mortar like that used for the slabs; lay a ring of it (11 ins. in diameter), about ½-in. thick and 4 ins. wide, on the support; press into this the brass pipe so that the faucet shall project well forward, and then set the small end of the big pipe section (clean and damp) into the fresh mortar ring; (a small half-round notch must have been previously chipped out of the edge of the glazed pipe to roughly fit over the brass pipe); then, immediately, with a trowel—a mason's pointing trowel is best—work the mortar with firm pressure up against the earthenware, inside and outside, so as to make a dense water-tight joint.

(4) THE FILTER SECTION.—Place the *intermediate* slab (with the small hole) over the lower section. On this set the upper pipe section into a mortar ring and work the mortar as before with pressure, so as to make the joint quite water tight all around. Be careful not to jar or loosen the lower section and its joint, so as to require doing the job again.

(5) PLACING THE FILTERING MATERIAL.—Carefully put into the bottom a layer of clean gravel stones, or pieces of crushed rock about ½-in. in diameter, to a depth of about 1½ ins.; above this a layer of smaller gravel about pea-size to the depth of ¾-in. more; then a ½-in. layer about the size of shot; then a 1-in. layer of coarse sand, from which all the fine dust must have been screened. We thus have a graded drainage stratum about 3½ ins. deep. The necessity of this careful grading is to prevent small particles from the body of the filter working down to clog the outlet. The filter proper is a mass of rather fine sand, as uniform in size as can be found, well washed by stirring in a pail and pouring off the dirty water, and evenly placed in horizontal layers, up to the enlargement at the bell end. It is well to put in some excess to allow for settlement, so that the final surface shall be about an inch below the over-



A Home-Made Slow Sand Water Filter.

flow. The latter may be of ½-in. lead pipe, carefully cemented into a notch chipped out of the edge of the bell, and extended to any convenient place where the drip may run away. In the center of the sand surface place a piece of brick or slate or broken earthenware about 3 ins. square, to check the impact of the incoming stream and prevent disturbance of the surface of the sand.

VARIOUS ARRANGEMENTS OF THIS DEVICE.

(a) If the householder already has a convenient cistern, clean beyond suspicion, the lower part or receptacle of filtered water may be omitted and proper means used to convey the effluent from the filter to his cistern. If he also has water served from a pipe, we have the simplest case of all, where the essential parts are only the filter with its cover, a piece of small pipe or tubing to deliver the water, a small valve or pet-cock to regulate the flow, and the overflow pipe.

(b) If the water to be filtered comes from a well or brook, the supply tank is needed, as shown in the drawing marked A. This is constructed so as to deliver the water "under a constant head," that is, at a uniform rate—which is an essential condition of operation of the filter. The principle of action is that of the well-known "Mariotte's bottle," described in works on experimental physics. The vessel should be made of sheet copper, or tinned copper if preferred, with a top slightly rounded for strength, and a cap or stopper at the center to be screwed in so as to be air-tight. Near the side a small tube ¼-in. or ⅜-in. in diameter is fastened to the top with an air-tight joint, and extends to within 3½ in. of the bottom. This distance must be as exact as possible, as it is the actual head which determines the rate of discharge. A small hole, 1-16-in. in diameter, must be smoothly drilled at the center of the bottom. To start the operation place the tank centrally with its discharge opening over the center of the cover slab. Remove the stopper and fill the tank and immediately replace the stopper, screwing it down air-tight. The atmospheric pressure, acting through the small tube, will maintain the pressure constant, until the water surface falls to the lower end of the tube—when the tank should be refilled. Air will enter through the tube with a slight gurgle, to replace the water discharged.

With dimensions here shown probably a little more than 30 gals. per day (24 hours) will flow through the filter and about 40 gals. from the supply tank, which allows for a waste or overflow sufficient to keep the filter full. The supply tank shown would contain more than 10 gals. above the lower end of the inlet tube.

(c) If it is deemed advisable to have a "telltale" to show the level of the water in the cistern, and also to indicate when the filter is becoming clogged, the extra fittings needed and their arrangement are plainly shown in the drawing marked B. In this case care must be taken to get the fittings in proper line so as to hold the glass tubing without strain; also to cement the small T's into the notches in the earthenware with water-tight joints. Note that the upper T must be closed by a proper brass plug to exclude unfiltered water from the tube.

(d) Twelve-inch earthenware pipe would give a capacity more than 40% greater, but would require two persons to handle the lengths. Thirty gallons per day of water used strictly for drinking and cooking would suffice for an ordinary family. The 3-ft. lengths of earthenware pipe would give greater storage capacity and greater depth of sand in the filter, but would require an awkwardly long reach in the building of the apparatus.

NECESSARY CARE AND ATTENTION.

Although the filter thus described requires comparatively little care, yet a domestic utility so important as this must be attended to as required.

To renew the action of the filter when too much clogged, scrape off the sand and deposit at the top to a depth of about ½ in. or more, as may appear needful. Replace this by as much clean sand, or by that which was removed, after carefully washing it. With ordinary water, not noticeably turbid, such scraping may only be needed at intervals of ten or twelve weeks; but more frequent treatment must be given under less favorable conditions.

FILLING.—Properly to start such a filter it should be filled from below with water already filtered. But in the ordinary household it would not usually be practicable to accomplish such conformity to theoretical requirements. Hence no provision is made for such filling, excepting the arrangement in style B with the telltale tube, where, by turning up the bend and screwing in a length of pipe, water may be run in at the bottom through the glass pipe, and so the air will be forced upward through the sand.

Ordinarily the full bacterial efficiency only comes in any case some days after starting. If contamination of the water is suspected, then all that is used for the first filling should be boiled and put in from a clean vessel.

When the feed tank is used, evidently any omission to keep it in proper action—allowing it to empty itself—will result in irregular action of the filter; that is, a total or partial emptying of the filter and an objectionable frequency of refilling. Constant flow should be maintained if possible, at least during daytime.

COST.

Style B, without telltale fixture:	
Two lengths of 10-in. earthenware pipe	$1.32
Faucet, ½-in., brass	.75
Brass tubing	.15
Lead pipe, ½-in., 4 ft. and 2 ft.	.60
Pet-cock, brass	.15
One ½-in. elbow	.12
	$3.09
35 lbs. Portland cement and sand to suit	.41
	$3.50
Labor, if hired, say	2.50
Style B (simple)	$6.00
For style A, add for copper tank	4.50
Style A (simple)	$10.50
For first case with other fittings (brass):	
Two glass tubes	$0.30
Two unions, ½-in.	.50
Three T's, ½-in.	.50
Two bends	.25
Extra length of ½-in. tube	.15
Extras, say	$1.70
Brought down	6.00
Style B, with all extras	$7.70
Style A with all the extra fittings, $10.50 + $1.75	$12.25

Of course such a statement is only approximate. The cost of materials and skilled labor will vary somewhat

*Condensed from the New Hampshire Sanitary Bulletin, July, 1906.

†Director Thayer School of Civil Engineering, Dartmouth College, Hanover, N. H.; Member N. H. Board of Health.

with the locality, but the above may be considered a fair average. Nickel-plated fittings may be preferred.

DURABILITY.

As before stated, all the materials here used are not subject to deterioration in this combination. If the upper layer (3 to 4 ins.) of the sand is renewed as the case requires, the action of the filter should continue indefinitely. The writer has had such a filter in use for several years with no apparent loss of efficiency. This statement needs qualification because of the fact that tests of bacterial efficiency have not been numerous or systematic. But usual water analyses at the State Laboratory of Hygiene have invariably shown that the quality of the water was of the best.

CONCLUSION.

The foregoing contrivance is presented to the public, through the New Hampshire State Board of Health, in the hope and belief that it answers the question which many find so perplexing—how to secure, at moderate cost and by simple apparatus, a pure drinking water from sources which are dangerous or suspected. The principle of its action has been proved and approved by tests and experiments continued through many years—in many countries; and in the form here described it has been in successful use by the writer more than a decade. But let the reader beware not to leave the construction or operation of such a utility to the ignorant incompetence or willful indifference and neglect of untrustworthy help. It demands intelligent supervision and the occasional attention prompted by a proper understanding of what it ought to do from day to day.

THE COST OF STEAM SHOVEL WORK IN RAILWAY BETTERMENT.

By S. T. Neely, C. E.*

Probably no important railway system in the United States has not on its right-of-way one or more steam shovel outfits engaged in the work of bettering grades, making cut-offs or double-tracking. On account of many intricate manipulations necessary to get the appropriations for this kind of work, authorization to go ahead is generally given about the time the work should have been completed. Under the engineer or superintendent of construction, a construction corps is hastily organized, certain profiles are run and a great many estimates made.

Contracts are then let and shovels are "cut in," often, within the writer's experience, before the slopes are set or the final grades established. It is not the province of this article, however, to deal with this part of the subject, except to note that it is advisable to make thorough preparation; to have all necessary additional right-of-way purchased and fenced; to have as much of the new masonry completed as possible, and certainly to have the new work completely staked and witnessed before the shovel is allowed to begin.

STEAM SHOVEL LIMITATIONS.

In making up plans and estimates for work which, from the nature of the conditions, must be handled with steam shovels, the fact that a shovel works only within certain limits is of first consideration. Fig. 1 is a typical cross-section showing a shovel loading to its extreme lift and cutting to its extreme width. The measurements are taken from a 65-ton Bucyrus shovel, in actual operation, loading 12-yd. Western dumps of standard gage. All the figures given in the article refer to work actually done with this equipment.

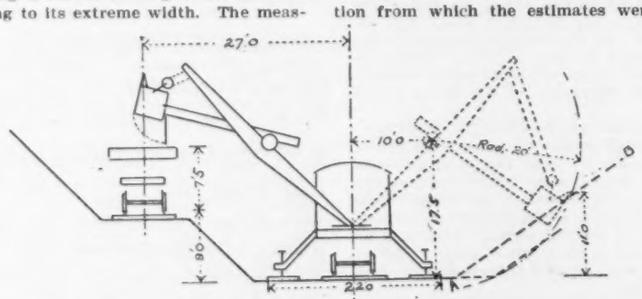


FIG. 1. TYPICAL CROSS-SECTION OF STEAM SHOVEL, SHOWING EXTREME LIMITS OF ITS EXCAVATION.

The limitations referred to are, then, as follows: The extreme depth taken at one cut without blocking up is approximately 9 ft. below the top of the rail of the loading track, and this extreme is too deep for the fastest work. The narrowest cut in which the shovel can move is 22 ft. at the bottom, the widest about 30 ft. While "holding in" to a narrow bottom, it is possible for the shovel engineer to follow the line A-B, making a 1½ to 1 slope, 11 ft. in height; but in reaching out to full width, the slope could be carried for only about 5 ft. in height. At a height of 17 ft. the shovel reaches out 57 ft. from the center of the loading track; and above this enough material will fall to make at least a vertical face. Finally, if the cut is to be deeper than 9 ft. below the track, the bottom width must either accommodate a track and the shovel (necessitating about 40 ft.), or have a shelf left on the slope, as shown in Fig. 1.

It is a question of endless dispute between contractor and engineer whether the former is to be paid for material taken outside of specified cross-sections (which are generally in such cases too narrow to be excavated in any manner by a steam shovel). Sometimes the lower part of the section which is too narrow for shovel work, is finished up with teams. On betterment work this is open to two objections: (1) It is too slow. (2) It is too expensive. Very often, moreover, it is impracticable if not impossible. As it is an undeniable fact that a cut can never be too wide, the cross-section of the cut to be taken out with steam shovel should be so designed as to render the work practicable.

Fig. 2 is an actual cross-section taken from work now in progress. Loading was done on the traffic track "A" and the shovel was "cut in" on the right of the track without any further reference to the cross-sections than orders to "stay inside the slope stakes." The offset of 22 ft. from the center of the old main to that of the new was governed by the height of the fill at the end of this cut. In Fig. 2 the heavy unbroken lines indicate the theoretic cross-section from which the estimates were made, and which was staked out; the dotted lines show the cross-section actually excavated. The payment for the whole amount of earth outside of the full line and inside the dotted one was in dispute, as the specifications read, "no payment will be made for any material taken outside the slopes except where absolutely necessary;" but fortunately, owing to a slide in the high embankment beyond, it was necessary to "harrow" from this cut before the embankment was completed and, of course, payment was allowed for the harrowed material.

Fig. 3 is an ideal cross-section which shows how nearly the practical would have conformed to the theoretical if any attention had been paid to the first "cutting in" of the shovel.

Fig. 4 is a profile of this work along the center line from which the section in Fig. 2 was taken. In all the considerations of cost which follow, the amounts refer to actual work done while the shovel was cutting from C to D and the material being hauled to and placed in the embankment A-B, which was also a parallel offset line, 22 ft. center line to center line.

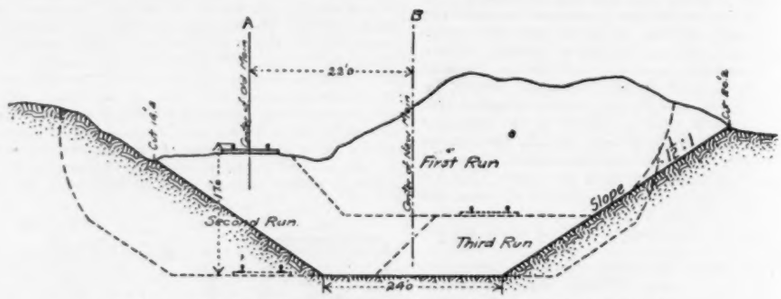


FIG. 2. CROSS-SECTION OF STEAM SHOVEL EXCAVATION.
(Solid lines show intended final cross-section; dotted lines show section actually cut out by shovel.)

COST OF STEAM SHOVEL WORK UNDER ABOVE CONDITIONS.

First cost:	
Equipment.	
One 65-ton steam shovel	$10,000
Three standard gage "dinky" engines @ $2,200	6,600
Twenty 12-yd. dumping cars	14,000
One spreader (Jordan)	2,400
Extra parts carried	1,000
Tools (jacks, shovels, bars, etc.)	1,000
Total cost equipment	$35,000
Annual cost.	
Interest at 6%	$2,100
Renewal in five years	7,000
Total	$9,100
Cost per month for interest and renewal	$750
Cost per day for interest and renewal	25
Operating expenses.	
Coal per day:	
Three engines, two tons each, at $2.00	$12.00
One shovel, two tons, at $2.00	4.00
Total	$16.00
Waste and oil for 3 engines and 1 shovel, at 75c.	$3.00
Water, 10 M gals., at 50c	5.00
Total for fuel and oil per day	$24.00

Actual Daily Pay-Roll:

Occupation—	No. of Men.	Rate.	Pay.
Foremen	2	$3.75	$7.50
Timekeeper	2	2.35	4.70
Shovel engineer	1	5.00	5.00
Craneman	1	2.50	2.50
Fireman	1	2.25	2.25
Watchman	1	2.25	2.25
Pitmen	6	2.00	12.00
Dump laborers, track raisers	30	1.75	52.50
Track gang	13	1.75	22.75
Locomotive engineers	3	3.50	10.50
Firemen	3	2.00	6.00
Brakemen	3	2.50	7.50
Railway conductor	1	4.00	4.00
Flagmen	3	2.00	6.00
Car doctor	1	2.00	2.00
Blacksmith	1	3.50	3.50
Blacksmith's helper	1	2.00	2.00
Superintendent	1	5.00	5.00
Telegraph operator	1	2.00	2.00
Total pay roll			$159.95

Total Daily Expenses:	
Interest and renewal	$25.00
Fuel and water	24.00
Pay roll	160.00
Total daily expenses	$209.00

RAINY DAY EXPENSES.

From tabulated reports of the Weather Bureau for the past 33 years, the writer figures that in the greater part of the U. S. there will be, in all probability, ten rainy days in each month, distributed more uniformly throughout the year than is generally supposed. While many of these rains are doubtless showers which would delay the shovel work very little, others would necessitate a delay until the dumping ground dried out. Including stops for breakage, Sundays, etc., it is safe to assume that there will be ten days in each month when no work is done, while certain portions of the expense are just the same.

*Assistant Engineer Southern Ry., Atlanta, Ga.

Those expenses are as follows:

Interest and renewal			$25.00
Pay-Roll as follows:			
Occupation—	No. of men.	Rate.	Pay.
Foremen	2	$3.75	$7.50
Timekeepers	2	2.35	4.70
Shovel engineer	1	5.00	5.00
Craneman	1	2.50	2.50
Fireman	1	2.25	2.25
Watchman	1	2.25	2.25
Locomotive engineers	3	3.50	10.50
Firemen	3	2.00	6.00
Conductor	1	4.00	4.00
Superintendent	1	5.00	5.00
Operator	1	2.00	2.00
Labor of ditching, etc.	20 hrs.	17½	3.50
Total			$56.20
Fuel and oil for one engine			$5.00
Total non-working day expenses			$86.20

Expenses for one month:

20 working days, at $200.00	$4,180.00
10 working days, at 86.20	862.00
Total expenses for one month	$5,042.00

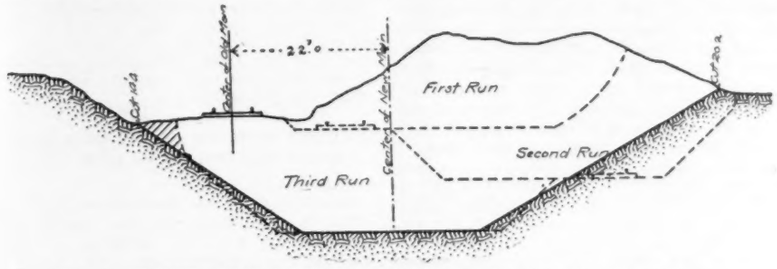


FIG. 3. THEORETICAL METHOD OF TAKING OUT CUT SHOWN BY FIG. 2.

MATERIAL MOVED.

Two of the locomotives were used in hauling the material from cut to embankment; in the present case, from C D on the profile, Fig. 4, to A B, an average distance of 12,000 ft. Each engine pulled ten 12-yd. cars (about its tonnage under the track conditions). The third engine was in constant use pulling the spreader, watering the shovel, switching, etc. The time of loading was exactly 35 minutes for each ten cars, six or seven dipperfuls being put on each car. The time of dumping and latching up was about five minutes, giving 15 minutes running time each way. In this case the empties were always waiting for the loads on one of the passing spurs (which were located at C and E), unless delayed by derailment or by trains on the main track.

On account of such delays, an average working day resulted in the disposal of 140 cars of material. These 12-yd. cars loaded full averaged in a month's run almost exactly 11 yds. of excavation. A day's run was 1,540 cu. yds. For 20 working days this would mean 30,800 yds., which was very close to the monthly estimate in this case.

The cost, then, including interest and renewal of machinery, for moving 30,800 yds. under these conditions was $5,042, or 16.4 cts. per cu. yd.

ANALYSIS OF COST.

Cost of Digging:	
Steam shovel, interest and renewal	$7.25
Two tons coal	4.00
Water	2.00
Waste and oil	.75
Shovel crew	12.00
Pitmen	12.00
¼ cost of superintendent, foreman, blacksmith, etc.	5.70
Total	$43.70
Non-working days:	
Locomotives and cars	$13.65
Fuel, etc., for one engine	5.75
Two crews and conductor	20.00
¼ superintendence	5.70
Total for one day	$45.10
20 working days at $81.60	$1,632.00
10 non-working days at $45.10	451.00
Total cost hauling 30,800 yds.	$2,083.00
Cost hauling one yd.	6.7 cts.
Cost of dumping and raising:	
½ superintendence	$11.40
Labor dumping and raising	52.50
Tools	2.00
Total for one day	$65.90
20 working days at $65.90	$1,318.00
10 non-working days at $13.40	134.00
Total for dumping and raising 30,800 yds.	$1,452.00
Cost of dumping and raising one yd.	4.7 cts.
Non-working days:	
Steam shovel	$7.50
Crew	12.00
¼ superintendence, etc.	5.70
	$25.20
Total for one month:	
20 days at $43.70	$874.00
10 days at 25.20	252.00
Total cost digging 30,800 yds.	$1,126.00
Cost of digging one yd.	3.6 cts.
Cost of hauling:	
Two locomotives and cars, per day	$13.65
Fuel, water, oil, etc.	11.50
Two engine crews, flagmen and conductor	24.00
Car doctor and track gang	24.75
¼ superintendence	5.70
Operator	2.00
Total for one day	$81.60

SPREADING.

In the work under consideration, the spreading was done with a Jordan spreader, described in Engineering News of recent date. On several low dumps the spreader would not spread low enough, and the dumps were finished with teams.

The actual cost of spreading with a Jordan spreader is:

Equipment	$2.00
Engine crew and two men	10.00
Fuel, etc.	5.75
	$17.75
Total for one month:	
20 working days at $17.75	$355.00
10 non-working days at $8.50	85.00
Total cost spreading 30,800 yds.	$440.00
Cost spreading one yard	1.4 cts.

Summary of cost yer yard:

	Per yd. cts.
Digging	3.6
Hauling	6.7
Dumping and raising	4.7
Spreading	1.4
	16.4

OVERHAUL.

Since it takes 35 minutes to load a complete train and 5 minutes to dump it, any length of haul which the train can run in 15 minutes allowing time for entering the passing switch does not figure as overhaul with this equipment.

The 12-yd. cars can be run 15 miles an hour with perfect safety. Allowing 3 minutes for switching, the natural haul would then be 3 miles. For each mile over 3, the delay to the shovel would be 8 minutes (4 minutes to go and 4 to return). The expense for one minute being 40 cts. (digging 1,500 yds. in 10 hours = 2½ yds. per minute, at 16 cts.), this would add $3.20 to the cost of each train-load of dirt (110 yds. making the cost of overhaul per mile 3 cts. However, with a permanent overhaul of any length, it will always pay to put on an extra locomotive, dividing the trains to 7, 7 and 6 cars. As it would take 25 minutes to load and 5 minutes to dump, each train would have 45 minutes to run and switch, allowing a haul of 5 miles at the additional cost of the following:

One locomotive (rented)	$5.00
Fuel, etc.	5.75
Crews	10.00
Cost of hauling 1,000 yds. per day	$20.75

making a cost of 2 cts. per yd. for 2 miles, or 1 ct. per mile overhaul.

Consideration must be had, however, of the fact that the increased number of trains and the greater distance hauled make the total delays much greater, so that 2 cts. per mile is a very reasonable price for overhauling in any case.

RAISING TRACK VS. TEMPORARY TRESTLE.

The material placed in the embankment A B (Fig. 4) was handled in the following manner: At first the dirt was side dumped from the old main track and spread until the new embankment was the same height as the old one, and of sufficient width to lay upon it an additional track. The dump was widened (by throwing this track) to the slope stakes at this elevation. The new track was then thrown to its final center and raised to its proper height. The force of 30 men actually handled over 30,000 cu. yds. in one month in this manner. The writer has had no experience in building temporary trestles, but if, at the start, a trestle had been built from A to B capable of carrying 12-yd. cars, the "dump gang" could have been reduced to eight men. The actual saving would have been the wages of 22 men per day, or $38.50. As 1,540 cu. yds. were handled per day, this would mean a saving at 2½ cts. per yd. As the trestle would average 10 ft. in height and the roadbed was 20 ft. wide, this 2½ cts. per yd. would allow 32 cts. per lin. ft. to pay for the trestle, which amount would probably not cover the item of labor. In case of a trestle 20 ft. in height and of sufficient length to allow the stringers to be used repeatedly, the saving per lin. ft. of 75 cts. would probably cover the cost, and the advantage of having a dumping ground in all weather would make the erection of a temporary trestle advisable. The writer is, however, greatly in favor of raising track in most cases of this kind. With a well-trained gang, using jacks of 24-in. lift and following the plan of beginning at the "far" end of the dump and carrying grade with a steep run-off, surprising speed and cheapness can be obtained.

The above costs were figures from the actual pay-roll of one day each, working and non-working, which, however, were chosen, because each represented an average day. The actual totals for the month's run from which these were taken were as follows:

No. of days worked	21
No. of days idle	10
	Cu. Yds.
Total 12-yd. cars loaded = 2,942, at 11 cu. yds =	32,362
Monthly estimate allowed	32,500
Total pay-roll for month	$3,951.73

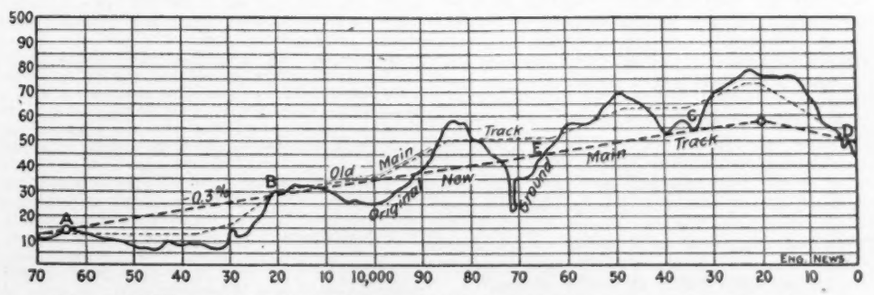


FIG. 4. PROFILE OF STEAM SHOVEL EXCAVATION ALONG CENTER OF NEW TRACK.

PUMPING WATER FROM THE MISSOURI RIVER is a feature of the work of the U. S. Reclamation Service in North Dakota. According to statements made by Mr. H. N. Savage, Supervising Engineer, three projects are now under way in the western part of the State. For two of the main projects electrical power will be used, the power plants being located at coal mines. The first installation of pumps will be on floating barges, which will accommodate themselves not only to changes in water level, but also to changes in channel. Pipes with flexible joints will connect the pumps with the main canal, short conduits being sufficient for the purpose. Wherever required, water will be pumped at substations.

DUPLEX LOCOMOTIVES.

Duplex locomotives, in which the driving axles are arranged in two separate groups, each having its own cylinders, are in use to a considerable extent and in many countries, being adapted to meet special requirements. The purpose of the design is to combine high power and adhesive weight with a number of axles and a short, rigid wheelbase, so as to limit the load per axle and at the same time to permit the engines to pass sharp curves. The engines in service range from those of light weight for narrow-gage mountain lines of light construction, to extremely heavy engines for heavy trains in main track service on divisions having severe grades.

In the Mallet duplex system, one group of driving axles is carried by the main frames, while the other group is carried by a swiveling steam truck. In the Meyer system, there are two steam trucks, connected together by a hinge or knuckle joint, so that as the first truck swings to or fram a radial position in entering or leaving a curve it helps to bring the rear truck also into position. In the Fairlie system, there are two entirely independent steam trucks; as a rule two boilers are also used, placed back to back on the continuous main frames, with the cab between them. The Mallet system is exemplified in this country by the huge 167-ton engine of the Baltimore & Ohio Ry. (Engineering News, June 30, 1904, and June 15, 1905), and similar engines are now being built for the Great Northern Ry. No engines of the other two classes are now in use here, although some Fairlie engines were used in the early days of the Denver & Rio Grande Ry. (when it was a leading narrow-gage system), and single-boiler Mason-Fairlie engines with one steam truck and one carrying truck were at one time used on local lines at Providence, R. I., and Coney Island, N. Y. The Fairlie engines are now used mainly in Mexico and South America, but in our issue of Dec. 21, 1905, we described a very heavy engine of this class (but with a single boiler) built by the Northern Ry., of France.

A notice of duplex locomotives would not be complete without mention of the Johnstone engines which were at one time in use on the Mexican Central Ry., but which, we believe, no longer exist. These engines were described very fully in Engineering News in 1892 and 1893.* They were peculiar in that while there were two boilers and two driving trucks the cylinders were all carried on the main frames, motion being transmitted to the axles through a system of levers and flexible joints. They were also peculiar in being compounds with the high-pressure cylinders placed inside the low-pressure cylinders. In all these cases, the main frames are continuous, but mention may also be made of some duplex locomotives used in this country and in India, each of which consists of two identical tank engines coupled together back to back, and fitted with an arrangement of reversing and throttle levels for operating both engines simultaneously, the cab being between the engines. A Baldwin engine of this kind for the McCloud River Ry. (California) was described in our issue of June 28, 1900.

Among the latest engines of the Fairlie double-truck double-boiler type are two recently built by the Yorkshire Engine Co., of Sheffield, England, for a railway of 30 ins. gage in Bolivia. They are intended to ascend grades of 2.86% and to pass curves of 230 ft. radius. Fig. 1 shows the general design and arrangement of the engine, while Fig. 2 shows a sectional elevation and plan of one boiler and steam truck, forming one-half of the locomotive. The two fireboxes are fitted between plate frames which also carry the tanks and boilers; these frames are connected at each end by a transverse girder or bolster, upon which the front end of the boiler rests, while the lower part forms the center bearing on the bolster of the steam truck. The fireboxes are of copper, with the Belpaire system of staying. The locomotive is of the 0-6-6-0 class, and each steam truck is an independent six-wheel simple engine, with outside cylinders and the Walschaert valve gear; the rear or inner axle of each truck is the main driving axle, and the middle axle of each truck has blind tires. The general dimensions are as follows:

Class of engine (double steam-truck)	0-6-6-0
Driving wheels (12), diameter	2 ft. 6 ins.
Wheelbase, each truck	6 ft. 0 ins.
Wheelbase, total	29 ft. 4½ ins.
Distance c. to c. of trucks	21 ft. 10½ ins.
Length over all	40 ft. 6 ins.
Weight in working order	116,700 lbs.
Cylinders (2 to each truck)	12½ x 16 ins.
Boilers (2) diameter	3 ft. 5 ins.
Boilers, rail to center line	4 ft. 10½ ins.
Working pressure	160 lbs.
Fireboxes (2); length, 3 ft. 1¾ ins.; width	3 ft. 8 ins.
Tubes, number (in each boiler)	106
Tubes, length (in each boiler)	9 ft. 6½ ins.
Heating surface (both boilers)	1047.00 sq. ft.
Grate area (both boilers)	21.66 sq. ft.
Height, rail to top of smokestack	10 ft.
Water in 4 side tanks	1,800 U. S. gallons
Coal	2 tons

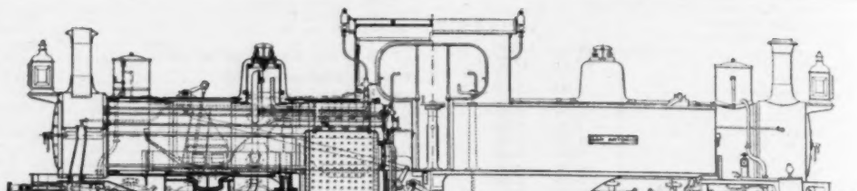


FIG. 1. SECTIONAL SIDE ELEVATION OF DUPLEX LOCOMOTIVE OF THE FAIRLIE TYPE FOR BOLIVIA.

Our illustration is reproduced from "Engineering," of London, and the following additional particulars are also taken from that paper:

The trucks each have six wheels, all coupled, the tires of the middle wheels being flangeless. Each truck carries a pair of cylinders, fitted with outside Walschaert valve-gear. A steel casting is placed between the frames, being recessed to form a socket for the pivot on the carrier frames. A radial slide is arranged at the back end of each truck for the carrier frames, and is fitted with suitable springs to minimize any tendency to rock. The difficulty of the reversing-gear, due to one end of the swing link being attached to the carrier frames, and the other to a moving truck, is overcome by placing the reversing-shaft at the top of the tanks, thus obtaining a very long swing-link, and consequently a small versed sine; this practically obviates all slip in the die due to movement of the truck when rounding curves. The two gears are coupled, and actuated by a screw which is placed in the middle of the foot-plate.

The arrangement of the steam-pipe is a decided improvement on the older type. Hitherto the chief weakness of the Fairlie engine has been in the number of expansion and ball-and-socket joints, and the difficulty of keeping them steam-tight. Formerly, steam was taken from the smoke-box tube-plate to a casting which projected from the bottom of the smoke-box, and formed (together with one end of the steam-pipe) a ball-and-socket joint; the other end of this pipe ran to a casting fixed in front of the truck center, with which it formed another ball-and-socket joint. This pipe also had a gland expansion-joint to enable the pipe to slide freely. Another expansion-pipe returned from this casting, on the truck center, and was flanged at one end to join a breeches-pipe which was connected to the cylinders. In the older types one of the chief difficulties in keeping the joints tight was due to the large amount of lateral movement in the ball-joints when the truck was on a curve, owing to their being placed so far away from the truck center. Theoretically, the correct place to put this joint is directly under the truck center, there being the least movement in this place, and this fact has been recognized in the present design, in which steam is taken from the side of the boiler by means of a copper pipe which terminates in a ball exactly under the center of the truck, where it fits into a socket on the end of another pipe which runs direct to the cylinders. As there is only one ball joint, in which (due to its position) there is practically no movement, and as this joint is also asbestos-packed, there is no trouble in regard to keeping it tight. All these pipes are carefully lagged with asbestos, as a preventative against condensation. The exhaust-pipe is fitted with a ball at each end; these work in corresponding sockets in the smoke-box bottom and the breeches-pipe between the cylinders respectively.

The cylinder water cocks are actuated by a small steam cylinder which operates a shaft to which all the cocks for one truck are coupled, and is operated from a cock on top of the fire-box. The sand-boxes are placed on top of the boilers, connection being made to the trucks with flexible pipes.

*Engineering News, 1892 January-June, pp. 244, 302, 323, 360; 1893, January-June, pp. 4, 129.

THE DEPTH OF WATER ON THE MITER-SILLS OF THE LOCKS FOR THE NEW YORK STATE BARGE CANAL.

By way of further elucidation of the way in which it comes about that the locks on the New York Barge Canal are to be very materially widened, as compared with the original plans, without any increase in water depth, we give below some extracts from advance pages of the annual report for 1905 of Mr. Henry A. Van Alstyne, State Engineer of New York. The first of these is as follows:

SIZE OF LOCKS.

Chapter 147 of the laws of 1903—known as the Barge canal improvement law—required that all locks should have a clear width of 28 ft., with a minimum depth of 11 ft. of water over the miter-sills. Under this law plans had been prepared and two contracts let for locks of 28 ft. width and 12 ft. depth. This law, however, was amended by chapter 740 of the laws of 1905, which permitted these dimensions to be increased, but did not definitely fix the size. After very careful investigation and consideration the width decided upon was 45 ft. and the depth 12 ft., despite the persistent recommendation of the State Engineer and the Advisory Board of Consulting Engineers that a depth of 14 ft. be adopted. Before reaching this decision a very thorough study was made of the widths of locks on canals of a similar character, previously built in the United States and Europe.

Careful consideration was given to the fact that the width of the canalized, natural waterways was sufficient for boats 43 ft. wide to pass each other, throughout about 92% of the distance between New York City and Rouses Point, at the northern end of Lake Champlain, and about 85% of the distance between New York City and Oswego, on Lake Ontario, or about 76% of the total length of the proposed Barge canal—including the Erie, Champlain and Oswego branches, and covering the distance from New York City to Rouses Point, Oswego and Buffalo. The fact that the locks on the Canadian system of canals were 45 ft. in width and had 14 ft. depth of water on the miter-sills was also considered, especially since the New York canals are connected with the Canadian system by Lakes Erie, Ontario and Champlain, with a possibility that Lake Champlain may be connected with the St. Lawrence River at Montreal at some future time by a Canadian canal, which would probably have the same dimensions of lock. Consideration was also given to the great increase in the carrying capacity of barges having a width of 43 ft. over those of only 27 ft. in width.

Then follows correspondence, in June, 1905, between the Canal Board and Mr. Van Alstyne, requesting and transmitting the opinion of the Advisory Board of Engineers on the matter of lock enlargement. This opinion, in the form of strong recommendations for enlargement, was printed in our editorial pages for July 26, 1906. Following the opinion, Mr. Van Alstyne explains how and why it was that the enlargement, "despite the persistent recommendation" of the Advisory Board and himself, was not carried out, as follows:

As chapter 147 of the laws of 1903 in section 6 provides that "no alteration shall be made in any such map, plan or specification, or the plan of any work under contract during its progress, except with the consent and approval of the Superintendent of Public Works and the State Engineer," it was impossible to legally get revised plans for contracts already let, before the Canal Board, without the consent of the Superintendent of Public Works. As that official would not approve of revised plans that provided for more than 12 ft. of water on the miter-sills and, moreover, as it was evident to the State Engineer that the majority of the Canal Board would not approve such new plans, even if properly placed before them, it was decided by the State Engineer to adopt the following governing dimensions for locks on the Barge canal:

Length between hollow quoins, 328 ft., this minimum dimension being fixed by law; clear width, 45 ft.; minimum depth in lock chamber on miter-sills, 12 ft.

At a meeting of the Canal Board held on Aug. 8, 1905, the State Engineer presented plans for contract No. 3, on the Champlain Canal, which increased the width of locks contained in that contract from 28 ft. to 45 ft., and provided for a depth of 12 ft. of water on the miter-sills. These revised plans received the approval of the Canal

Board by a majority of five to one. Revised plans for contract No. 2, increasing the width of locks No. 2 and 3 from 38 to 45 ft. and providing for a depth of 12 ft. of water on the miter-sills, were subsequently approved by the Canal Board. Since this date all plans for new locks have been made and approved with these governing dimensions. Before a final decision was made to increase the dimensions of the locks, I asked Mr. William B. Landreth, Special Resident Engineer, to make a careful investigation and to report as to whether a sufficient quantity of water could be obtained for supplying the Rome summit level with the changed conditions involved in the use of larger locks. Mr. Landreth's report is printed as an appendix to this report, together with the review of this report by Mr. Emil Kuichling, Consulting Engineer, to whom the matter was referred for his advice. [These reports are not yet at hand.—Ed.]

The plans for the locks that were to be 28 ft. wide provided for the use of a form of wooden lock-gate, but the new plans, which require a width of 45 ft., call for the use of steel for their gates.

It is to be noted further that, according to Mr. Van Alstyne, a lock depth of 14 ft. could not be fully utilized without a canal depth of 15 or 16 ft. for the entire length of the canal, which would involve deepening the prism 3 or 4 ft., as well as deepening the channel of the Hudson River from Hudson to Troy and also deepening the southern end of Lake Champlain. The large expenditure of money, at some future date, which this deepening would involve, was not considered justified by the canal board, it is said.

PLANS FOR PROPOSED WATER SUPPLIES IN OHIO must be approved by the State Board of Health before construction can be entered upon. As a preliminary to such approval, a blank form, prepared and supplied by the Board, must be filled in. A copy of one of these forms has been sent to us by Mr. R. Winthrop Pratt, Chief Engineer of the Board. Besides general information regarding the municipality concerned in the proposed works, the applicant for the approval of plans must submit estimates of cost, itemized where possible; reason for installing new works; maps; detail plans of ground water collecting works and of purification works if any; full information regarding impounding reservoirs, including whether or not bottoms are to be stripped, character of the drainage area, names and populations of cities, villages and public institutions on the drainage area within 20 miles of the intake, and method of sewage disposal for the same; in the case of filtration works, besides other information required, the applicant must state, where the plant is to be installed by a private company, "what guarantee of efficiency has been made and what arrangements have been or will be made to determine such efficiency"; a statement must also be made, regardless of ownership, as to "what arrangements have been made in regard to providing for continuous expert management of the plant, and for the daily analysis of raw and filtered water."

THE GERMAN CAST-IRON PIPE SYNDICATE, which was organized as a share company a few years ago, has arranged to continue its existence until March 31, 1908. Its headquarters are at Cologne, Germany. It is governed by a managing committee, which is appointed by a council, the members of which represent the parties to the agreement. All the output of the firms comprising the syndicate, with the exception of socket pipes of special form in small quantities, must be sold to the syndicate, and all orders and inquiries are to be referred to it. The production of each plant is allotted on a percentage basis; if a new firm is admitted into the syndicate the council determines the amount of its allotment and reduces that of the old members proportionately. If the sales of wares of any plant are in excess of its allotment, a fine must be paid to the syndicate; those works whose sales were less than their allotment, receive, on the other hand, an indemnity. The syndicate is the sole buyer of the products of its members, and likewise the sole vendor of their wares. A prearranged price is paid to the makers in the case of each contract and for each article; it is based upon normal market rates. In making sales, the syndicate takes into consideration the relative geographical situation of the customers and the various works, and also any special business relations between them. Export sales, however, are on a different basis. The transaction passes so far as possible through the hands of the syndicate, which ratifies the contract and controls the deliveries; but the amount of this business does not affect the allotment of the works concerned, for the inland market. The settlement also is made to the firm which sells the goods. From the monthly accounts of each member a certain proportion is retained by the council to defray the expenses of management, etc. As a guarantee for the fulfillment of its obligations to the syndicate, each member makes a deposit of from $1,000 to $1,250. The above information is derived from "The Iron and Coal Trades Review," of London, Eng., July 13, 1906.

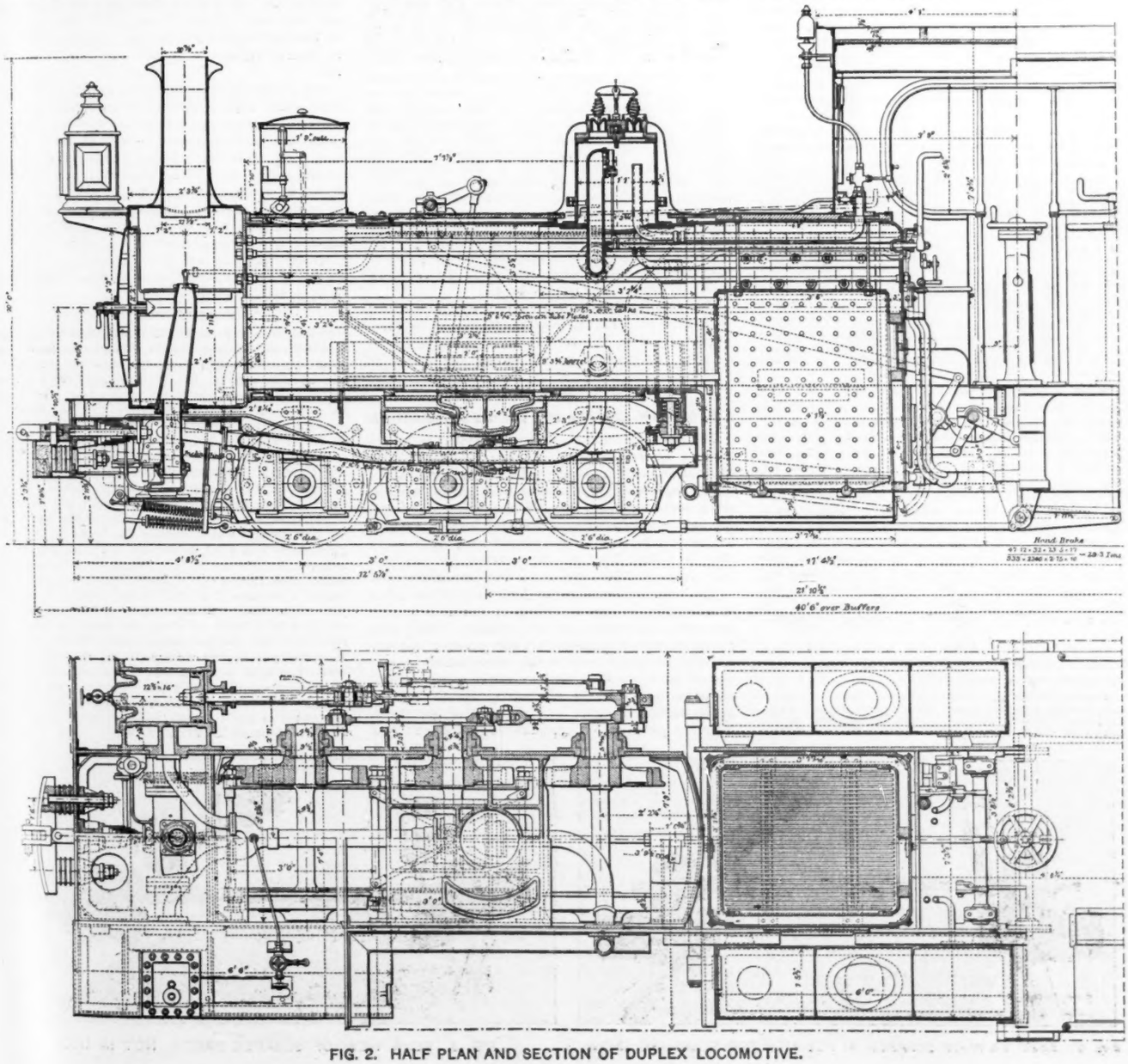


FIG. 2. HALF PLAN AND SECTION OF DUPLEX LOCOMOTIVE.

THE SANITARY CONTROL OF FISHING IN THE WATER-WORKS RESERVOIRS OF MIDDLETOWN, N. Y.

There have been a number of instances in different parts of the country, of late, of differences of opinion as to whether or not sanitary prudence dictates the prohibition of fishing in water-works reservoirs. Where the matter has received serious consideration in the past, it has, at least until quite recently, been the custom for the local authorities to allow more or less fishing, but generally under strict control. A desperate fight was made in Massachusetts, a few months ago, to secure legislation which would virtually take the control of this subject out of the hands of local water-works authorities. The proposed bill was defeated, through the active efforts of a number of sanitarians, including Prof. Wm. T. Sedgwick.

Within the past year or so there has been considerable agitation over this subject at Middletown, N. Y. Press dispatches indicating that there was a decided controversy over the matter between local and state authorities led us to apply to the New York State Department of Health for information as to the exact facts in the case. In response to our application, we have received the following statement from the Department:

Under the provisions of the Public Health Law of the State of New York giving the state department of health power to adopt rules and regulations for the protection from contamination of public water supplies, and at the request of the board of water commissioners of the city of Middletown, such rules and regulations for the protection of the water supply of the city of Middletown, N. Y., were adopted by the state commissioner of health May 30, 1903.

These rules were formulated after a careful examination of the local conditions and contained, among other provisions, the following:

Boating and Fishing. (15) Boating, fishing from boats, from rafts, from the shore and through the ice are hereby prohibited in any and all of the reservoirs of the Middletown water supply.

The Board of Water Commissioners of Middletown, when necessary to regulate or diminish the number of fish in any of the reservoirs, or when in their opinion such privileges may be extended without endangering the purity of the water supply, are hereby authorized to permit boating or fishing or both under explicit regulations and restrictions. Such permit, regulations and restrictions must be first approved, in writing, by the State Commissioner of Health.

A violation or non-compliance with any of the restrictions or regulations under which such permit for boating or fishing is issued shall be construed as a violation or non-compliance with this section of the rules and regulations.

A set of regulations and restrictions, under the above section, were submitted to former Health Commissioner Lewis last year by the water commissioners of Middletown, asking that they be approved by the state commissioner of health in order that the board might issue permits to allow fishing in the reservoirs of the city. Such permission was refused after a careful consideration of the question, and the application was renewed before the present commissioner of health in 1906. Subsequently a public hearing was held in Middletown, and a careful examination of the reservoirs was made. After giving the matter careful study, the application to allow fishing in the reservoirs was denied on the ground that the restrictions could not be properly enforced and that the interests of the health of the people of the city were best to be subserved by refusing the application.

The water commissioners then passed a resolution, which they asked to have approved by the common council, which read as follows:

Resolved, That our citizens shall be given the privilege of fishing in our public lakes, subject to such rules, regulations and restrictions as may be approved by the Board of Water Commissioners of the City of Middletown, N. Y., all made subject to the Fish and Game Laws of the State of New York; also subject to, and in full conformance with the Public Health Laws of the State of New York, the same to be in full force and effect when ratified and finally approved by the Common Council of the City of Middletown, State of New York.

The matter was immediately brought to the attention of the commissioner of health. It being alleged that the water commissioners intended to put the resolution into effect on the ground that the state department of health had no jurisdiction over the water supply, the case was placed in the hands of the attorney-general, who sent Deputy Attorney-General George H. Pierce to Middletown, in company with the Secretary of the State department of health, Mr. A. H. Seymour. On the night the ordinance in question came up a statement of the legal aspect of the case was laid before the common council, the powers of the health commissioner were recited and the council was assured that the law would be fully enforced. The meeting resulted in the resolution being laid on the table for two weeks.

The final results of this contest will be awaited with interest. Dr. Eugene H. Porter is commissioner of health and Mr. A. H. Seymour is secretary of the department of health, the offices of which are at Albany, N. Y.

FIG. 1. VIEW SHOWING ROOT SCRAPER ATTACHED TO LOCOMOTIVE.

A NEW SNOW SCRAPER FOR USE ON LOCOMOTIVES.

The Root locomotive spring scraper is a device to be attached to locomotives for cleaning the track and frogs of snow, thus preventing the compression, by wheels and wheel flanges, of snow into ice with its attendant troubles. While but lately adopted for this service a similar device, for use on street and interurban electric cars, has been on the market for the last four years and has given the best of satisfaction.

The scraper is supported just back of the pilot wheels (Fig. 1) and is raised or lowered, by the engineer, by means of air pressure, while any pressure can be applied to the scraper springs to meet the conditions of the snow, whether dry, wet or packed. The scraper requires practically no attention when in use, since, irrespective of the condition of track or the speed of the train, it is not affected by switches, crossing, etc. Not only is the top of the rail cleaned by this scraper but the snow is also removed 8 ins. each side of the rail, even with its top, and the rail flange is cleaned 1½ ins. × 1½ ins. below the top of the rail.

Fig. 2 shows the scraper in position for cleaning, while Fig. 3 shows its position when not in use. A strong spring in the air cylinder raises the blades, on the release of the air pressure, and holds them about 8 ins. above the top of the rails. It will be noticed that the blades stand at acute angles to the length of the rails in order to prevent them from being caught in the rail joints and at the same time to give a cutting motion in removing the snow.

These scrapers are being manufactured and marketed by the Kalamazoo Railway Supply Co., of Kalamazoo, Mich.

CHEAP GAS FOR LIGHTING AND POWER has been supplied for some time past at Widnes, England. The local authorities now propose to reduce the price to 1s. 4d. (28 cts.) and 1s. 1d. (26 cts.) per 1,000 cu. ft. to ordinary consumers, and to 11d. (23 cts.) per 1,000 cu. ft. for power purposes. At the same time gas would be supplied through prepayment meters at the rate of 1d. (2 cts.) for 44 cu. ft.

A TUNNEL WHITEWASHING MACHINE is in use on the Central London Ry., which is the principal "tube" underground railway in London. The apparatus is contained within a motor car, and at the end of the car is a circular frame carrying the heads of 20 flexible pipes, each head being fitted with a Y pipe forming two nozzles. In the car is a 1,200-gal. tank supplying a service tank from which a pump takes its supply, maintaining a pressure of 90 lbs. If the whitewash has been well screened there is no clogging of the nozzles. The car runs at a speed of about two miles an hour, and goes twice over the wall. Before whitewashing, the same apparatus was used to wash down the walls of the tunnels. The finish is not as good as by hand work, but is of course much more rapid and economical, and is satisfactory in regard to sanitary conditions and the improvement of the lighting in the tunnels. The apparatus was designed by Mr. E. P. Grove, Chief Engineer.

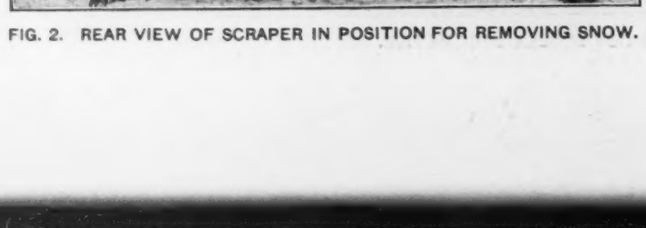


FIG. 2. REAR VIEW OF SCRAPER IN POSITION FOR REMOVING SNOW.

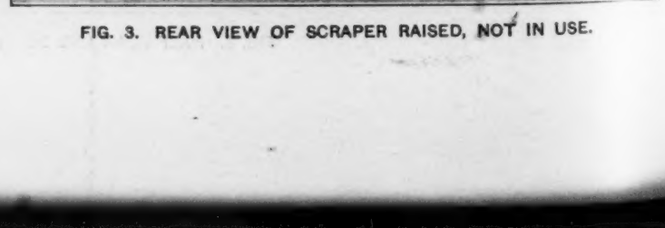


FIG. 3. REAR VIEW OF SCRAPER RAISED, NOT IN USE.

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The somewhat startling announcement is made in a recent issue of the Baltimore "News" that storm-water sewer inlets in that city are to be protected with gratings, so as not to "allow even the smallest child to pass through." We had not noticed, in connection with the vital statistics of Baltimore, that the infant mortality in that city was higher than in other portions of the South, but perhaps such is the case, for the "News" proceeds to state: "With such protection no child can be swept into the sewer by floods, as has too frequently been the case." By way of explanation it may be stated that the city of Baltimore, although having a population of more than half a million, is still without a sewerage system, except for some large storm sewers. These, it appears, are mostly trunk sewers rather than laterals, and as the surface drainage from large areas is admitted at relatively few points the inlets have been a number of feet in length. It further appears that some, at least, of these inlets have not been provided with gratings. Mr. Calvin W. Hendrick, Chief Engineer of the Baltimore Sewerage Commission, has recently made a report (giving rise to the comment quoted above) in which he states that some of the inlets are 10 to 20 ft. in length and 12 to 18 ins. high. Some of the long inlets he proposes to protect by horizontal and others by vertical rods. In view of the statement above, that Baltimore has no sanitary sewers, it is only fair to add in conclusion that definite steps have been taken to install a complete sewerage system, including purification works of an unusually comprehensive character.

Doubtless many engineers interested in water purification have speculated upon the possibility of adapting slow sand filters to household purposes, and have promised themselves to work out such a scheme, but have never found or taken the necessary time to do so. To all such, as well as to many other of our readers, the article entitled "A Sand Filter for the Home," by Prof. Robert F. Fletcher, published elsewhere in this issue, will prove of interest. The article, or, more properly, the bulletin, on which it is based is commendable not only for the design itself, but also for the detailed descriptions it gives of how the filter may be constructed and erected without the aid of specially skilled workmen. Some of the directions may seem very simple and unnecessary, but we are sure that they will prove helpful to many people, including not a few engineers. Both Prof. Fletcher and the New Hampshire State Board of Health are to be commended for such practical popular bulletins as the one just mentioned and as another issued not long ago on "Sewage Disposal for Country Houses."

SOME NOTES ON THE RECENT RAILWAY ACCIDENT AT SALISBURY, ENGLAND.

The recent derailment accident on the London & Southwestern Ry., of England, in which 27 passengers (of whom 23 were Americans) were killed, is a matter of sufficient importance to demand serious consideration, even in advance of official information, which will not be available for some time. English railways have a reputation of being notably free from serious accidents, but the number of such accidents seems to be increasing, and this particular accident serves to call attention to some of the modern developments in competition on English railways, which are usually considered as being very conservative.

A few years ago a "race to Scotland" was instituted by railways operating rival and competitive routes between London and the north, and there was considerable apprehension as to the safety of the high speeds which were maintained over long portions of the run. We do not now recall whether any accidents directly resulted from this, but the schedules were eventually lengthened and without any protest on the part of the traveling public. There is no disguising the fact that competitive service of this kind is very liable to result in accident of some kind. This may be, very probably, from some unforeseen cause, as where a too-zealous engineman may disregard orders to reduce speed to a certain limit at a certain part of the run.

The present competitive service between Plymouth and London is somewhat different from that of the service between London and Scotland, as the former consists of special trains carrying passengers from the transatlantic steamers while the latter consisted of daily trains in regular service. When transatlantic steamers began calling at Plymouth, both the Great Western Ry. and the London & Southwestern Ry. put on special "steamer express" trains to carry passengers to London, and there was, of course, direct rivalry between them. The distance was about 245 miles by the former and 230 miles by the latter, but the former afterwards shortened its route to 225 miles, while both roads have cut their schedules materially, the running time being about four hours.

Whether the Great Western ran a train to London for the passengers from the "New York" we do not know, and it does not affect the main question, which is that the London & Southwestern Ry. desired to carry its passengers to London in the shortest possible time, being induced thereto largely by the fact of its operating in direct competition with the other road. At Salisbury the train was running at a speed variously estimated at 60 to over 70 miles an hour, when it left the track on a sharp curve and was wrecked. The curve was near the foot of a grade of about 0.87%, and was equipped with a guard rail. One paper states that this was a compound curve of 792 ft. to 528 ft. radius, while another states that the chief engineer (in his evidence before the coroner's jury) gave it as a curve of 660 ft. radius. The superelevation of the outer rail is only 3½ ins., owing to the position of the high station platform and the girders of a bridge just beyond. It is stated that this superelevation is (under English practice) sufficient for speeds of 21¾ and 26½ miles an hour on curves of 528 ft. and 792 ft. radius respectively. Some of the witnesses considered the curve safe for 30 miles an hour, but the roadmaster put the limit at 18 to 20 miles an hour. It is evidently an exceptionally sharp curve for main track carrying fast trains. Even if it is a compound curve, it presumably has no easement or transition curve connecting it with the tangent, although a 792-ft. circular curve is a very sharp one to be taken at high speed, and it is to be noted that apparently the train was derailed immediately on striking the curve. The use of transition curves is not general in English practice, which in this respect is distinctly inferior to American practice.

That this curve was recognized as a dangerous point seems very evident, from the fact that a "slow" order had been given two years ago, when the first through trains were put in service, requiring enginemen to reduce the speed of trains to 30 miles an hour at this point. Not only this, but it seems that the running schedule for the fast trains (showing the time at which certain points must be passed) was such as to provide for a speed of 26 miles an hour in passing through Salisbury. Over 200 trains are stated to have been run on this schedule before the accident happened. There is conclusive evidence as to the high speed of the train, and as to this being primarily the cause of the accident. Whether it resulted secondarily from the wheels climbing the rails, from a broken rail, or from a disturbance of the track due to high speed, may never be known. An obstruction in the guard-rail flangeway is a possible (but not a probable) cause, and it does not appear that there was any evidence indicating a broken wheel or axle as a contributing cause. The examination of the engine showed that the continuous brake (vacuum brake) had not been applied, although steam seems to have been shut off. The conductor testified that he realized that the speed was excessive at this point, and tried to attract the attention of the engineman by slighly operating the vacuum brake valve, so as to move the needle of the gage in the cab. He did not actually apply this brake, however, but did apply the hand brake on his car. It is very evident that the engineman forgot or disregarded the "slow" order, and this is the more likely to have been the case since this was the first time he had driven a fast train which did not stop at Salisbury; he had, therefore, never had to slow down a fast train for this curve at the station, and might readily have forgotten an order issued two years ago. The jury evidently took this view, for while its verdict was to the effect that the accident was due to the excessive speed of the train, it recommended that in future enginemen assigned to trains running through Salisbury without a stop should be notified of the "slow" order for the curve when going on duty. One very prominent fact is that the accident occurred in direct or indirect consequence of high-speed competitive service.

Some writers in the English technical papers have tried to show that high-speed is really an element of safety as indicated by the easier riding of fast trains. Yet one of these same writers, recording a trip of this same "steamer express" on the same railway, a little more than two years ago, stated that the speeds were not allowed to exceed 70 miles an hour (although a speed of 80 miles was frequently made by other trains) for fear of alarming sensitive passengers. The two statements are certainly inconsistent, and the later one cannot by any means be accepted as a general proposition. It has also been claimed that neither curves in general, nor this curve in particular, are dangerous for high-speed running, and in proof of this it is stated that the Salisbury curve has been frequently passed smoothly and steadily by trains running at high speeds. But it is surprising to find any technical paper giving place to such a statement, and the existence of the "slow" order for this curve is indisputable proof that the railway officials realized this as being a danger point. In fact, every railway man knows that a sharp curve in a track operated by fast trains is in itself an element of danger; and the fact that such trains pass such curves without derailment is certainly no direct proof of safety. There is an indefinite factor of safety in all these cases, and as long as it is maintained there may be no accident. But every increase in speed reduces the factor of safety, and when very low it will take but a very slight influence (such as the jolting of a wheel, the lurching of a car, or perhaps a slight irregularity in the true line of the curve) to cause it to disappear altogether and lead to disaster.

As far as the track construction is concerned,

this was probably of sufficient strength, but at the same time it is to be noted that English track is the same now as it was 20 or 30 years ago, when the locomotives were considerably lighter than those of more recent date. In this connection we may call attention to facts brought out in the investigation of recent derailments on other English railways; in one case, it was found that the so-called 86-lb. rails had been reduced to 76 lbs. per yd. by wear, and that the railway company permitted the reduction to go as far as 72 lbs. before considering it necessary to renew the rails, even for main track carrying heavy engines and fast trains; in another case, the passage of fast trains around a curve had loosened the chairs (supporting the rails) from the ties to a serious extent; and in still another case, the removal of ballast from around the ties (without the precaution of flagging trains) caused a fast train to spread or burst the track at a frog.

The English type of locomotive with rigid wheelbase has been blamed, but most English railways now use trucks under their express locomotives, and as a matter of fact the London & Southwestern Ry. has been one of the earliest and most extensive users of the "bogie" truck. Indeed, the engine of the train in question was of the eight-wheel or 4-4-0 type (termed in England a "four-coupled bogie engine"). It had 79-in. wheels and probably weighed 60 to 65 tons. The tender was of large size for English railways, having a capacity of about 4,000 gallons of water and 4 tons of coal. It was mounted on trucks, but with much closer spacing and larger wheels than generally employed in American practice. This matter was discussed in Engineering News of June 9, 1898. One of the many rumors is to the effect that the tender did not ride easily and that this or the violent surging of the water in the tank may have caused the accident. In view of American experience with larger tenders on fast trains we do not give much weight to this, although it is very likely that not one but several factors contributed to or culminated in the accident. The train consisted of three passenger cars (on trucks) and a kitchen car with conductor's compartment. It has been stated that the cars were very light, and comparisons have been drawn between them and the ponderous Pullman cars operated on American railways. But the cars in question were first-class corridor and buffet cars of modern construction, mounted on trucks and probably having the usual English type of steel underframe. Such cars weigh from 30 to 35 tons, and the total weight of this train has been given as about 120 tons behind the tender. The underframe construction and the style of coupling are probably not so well adapted to resist buffing strains as are the American underframe and coupling, but it is not probable that these features were in any way responsible for the accident. There is no doubt that a weak point in English practice is that the car body is built independently of the underframe and simply bolted to it. It seems probable, however, that the cars were fully as strong as ordinary American day cars, and we have far too many examples of the wrecking and smashing of such cars in railway accidents to be warranted in making any claims of superiority for them as compared with English cars.

In the face of the usual conflicting rumors and statements it is satisfactory to know that this accident (like all other accidents, serious or trivial, on English railways) will be thoroughly investigated by government engineers, and that their official reports will be made public in due course.

Some day our own national government may undertake such investigations, but it is unlikely that the attempt will be made soon. Pending or in lieu of such action it may reasonably be expected that investigations of railway accidents by state railroad commissions, already practiced to some extent, will be extended in this country. The advantages of competent public investigations of this sort are too obvious to need discussion.

THE FIRST NEED OF FIRE-PROTECTION.

Building construction of to-day involves a large amount of consideration of protection against fire. The terms *fireproofing* and *fire protection* bob up at every point. Concentration of urban property values and greater pressure of insurance interests probably have much to do with this; but we conceive that the principal cause is the advance in knowledge and practice of fire preventive construction which has been made in the last two or three decades. Of this advance and the present progressive state of the art of fire protection many people know little or nothing; and in so far as they do know it, they probably charge much of it to the great fires of recent years and the general awakening of municipal effort. Yet of course the fact is that earnest study and discussion of the subject began many years ago and has continued uninterruptedly, finding only occasional focal points in great disasters, such as that of the Iroquois Theater, the loss of the excursion steamer "General Slocum" or the still inexplicable burning of Baltimore's business district.

The statement that fire preventive construction has been in active progress for a considerable time past is not inconsistent with the fact that our fire losses are assuming a relatively greater importance every year and are probably not diminishing in actual amount. We have to-day greater fire risks, more numerous and more serious causes for fire. We are also more careless in our individual life, in our handling of possible sources of fire; the oil lamp to-day is handled as carelessly as was the tallow candle in the early days of illuminating oils, and electric lighting wires are rarely associated in the lay mind with fire danger. Moreover, only a very small part of the present-day city bears the stamp of fire-protection progress. The few scattered structures which have profited by this progress are surrounded (in America) by dense aggregations of buildings which are not a particle better in fire-preventing or fire-resisting value than the buildings of a hundred years ago. Each modern so-called "fireproof" building stands in the midst of a combustible city, and does not perceptibly reduce the fire risk of that city.

We may look forward to a time when it will be universally recognized that to make a building safe against destruction by fire is a primary problem, coordinate in importance with the problem of making it safe against collapse. When that time comes, fire-protection will be a matter of calculation and closely-regulated design, just as the proportioning of columns, beams and other structural elements is at the present time. That such a time has not yet arrived, and that it is, in fact, a considerable distance in the future, must be conceded. It is no doubt true that the abstract desirability of more or less perfect security against fire damage is widely recognized, and in many quarters, even, there is full appreciation of its imperative necessity. None the less, the best that can be said for the public attitude toward fire-preventive construction is that it is one of good intentions only. Reasons for this are not hard to find; principal among them is perhaps this one: The chance of fire is always a chance, not a certainty, and this is an enormous temptation for the prospective owner of a building to save construction-cost by gambling against the chance of fire as far as the law will let him. A thousand succumb to this temptation for one that thrusts it from him.

The present state of fire-protection is sufficiently characterized by this frivolous attitude on the part of the public. The inevitable consequences of such almost universal playing with chance are, however, made distinctly worse by the very immature condition of our knowledge in the field of fire-protection. For, in spite of the progress that has been and is being made, our fire-protection knowledge is still very crude and undeveloped. Many cases arise constantly, in a city of any size, where owner, architect and all concerned are not only willing but even anxious to provide the best available construction for guarding against fire. They desire a perfect protection, which our present knowledge is unable to give them. To expect perfect protection is perhaps unreasonable. What we have a right to expect, however, is means for measuring the excellence of the results that can be provided. We should have a criterion, a test of protection against fire. But such questions as—How close can we approach practical perfection? What is the numerical value of the results we do achieve? What is the basis of estimating that value?—questions of this kind we are unable to answer. And our inability to answer them is complete proof of the crudity and immaturity of the art to which they are addressed.

In the matter of security against collapse, we know that structures designed in the best practice of the art are sufficiently strong, yet cannot be materially weakened without risk; in the matter of security against fire damage we have no such knowledge. Far from being in a position to discuss where we may reasonably set a limit to protective provision, we do not yet know how to protect sufficiently; the very best protection we can provide is good enough only because we are unable to provide better. San Francisco contained nearly two score of "most modern fireproof" buildings, but with unimportant exceptions all these were gutted in the conflagration of last April. [See the long article printed elsewhere in this issue, containing an abstract of a report to the National Board of Fire Underwriters on the San Francisco conflagration, with special reference to the fire-protection lessons of the fire.]

The commercial side of fire-protection offers us many materials and many methods which are claimed by their vendors to have the merit of making it possible to "build fireproof." Arbitrary prescriptions of various kinds are also available, some based on dogmas, some on superstitions, and a few of the better ones on repeated experience and experiment. In the absence of principles for estimating fire-protective values, these have all been used, and have engendered a certain feeling of confidence. When they came to the test of actual fire, the claims for most of these materials, methods and rules have been proven false. No better proof could be wished of the fact that fire-protection does not reside in materials or "systems" than the results shown at Baltimore and San Francisco.

The recognition of the last-mentioned fact is an important contribution to fire-protection knowledge. Forecasting the future of this knowledge, with an estimate of its present rate of progress, gives every confidence that, as concerns only our ability to protect against fire we shall in measurable time arrive at a satisfactory state. Just now our knowledge of fire-protection is advancing more rapidly than ever before, and there is every reason for believing that its progress will continue. Fears for the future on the score of inadequate technical knowledge are idle apprehensions.

The great need for the future is of another character than technical knowledge—it is a better public sentiment in matters of fire protection. The good intentions of the public, of which we spoke above, are generally only an academic matter, or even a polite fiction; and, as in the case of other good intentions, the road over them leads to no good end. The common view is that it is cheaper to insure than to protect, and, since protection is not absolute in any case, insurance would be necessary even with protection; consequently, insure, and spend as little money for protection as the authorities will permit. The difficulty of providing efficient protection by good design, construction and operation, as compared with protecting by insurance, and the gambler's chance of not having a fire, form a double temptation that is nearly always effective. To further discourage permanent investment in fire-protection, there is the strong feeling that the selling value of a structure is not materially increased by a high degree of protection as against inferior protection. The pub-

lic which comes to buy or to rent the building will not pay a higher purchase price or higher rent for complete fire-protection. A moral awakening of the public is needed in its attitude toward fire-protection. Professor J. L. Van Ornum says, in a letter printed in our correspondence columns this week: "The time has come when a definite movement toward systematically curtailing and preventing such losses should be taken." We emphasize the word "movement," and in the interpretation we would put upon it it means a revival—a smiting of the public conscience.

Two elements must be present in such an awakening: The first is the general appreciation by every part of the public, even down to the city alderman, that measures designed to guard against the outbreak or spread of fire are as important as measures for securing structural safety in buildings, and are only less important than public sanitation; the second is that fire-protection must be frankly and broadly recognized as a science, and a difficult and complex science. That idea of fire-protection (popular not only with the layman but with not a few engineers and architects) which identifies the conception "fire-protection" or "fireproofing" with the aggregate of "brick," "stone," "iron," "tile" and "concrete," must be replaced by the view that protection against fire is a matter of scientific study, concerned with definite phenomena and dangers, based on definite principles and dealing with definite laws; definite even though our present knowledge of these phenomena, principles and laws may be fragmentary or erroneous.

We lay less stress on the first element here, though it might with profit be discussed at length; for it seems to us that public respect for and deference to fire-protection must be preceded by a higher regard for it on the part of its own votaries, or those who come into working contact with various phases of fire-protection. So long as there is a large fraction of the engineering profession which believes that the key to the whole domain of fire-protection is some shibboleth, such as Tile, or Concrete, or Reinforced Concrete, or even Doe's (patented) System, or Roe's (patented) System, so long will fire-protection be kept from assuming its true rank as a science. And just so long will the public believe that fire-protection is a commercial thing—a thing that is bought and sold, like clay tile, or patented reinforcing bars. Therefore, if the present conditions of cities and city buildings is in urgent need of improvement against fire danger—and we believe with Professor Van Ornum and others that it is—let us by all means accord to fire-protection its proper rank as a science, a subject for study and research; and let us labor with definite purpose to establish that science or study on a firm basis of principle.

LETTERS TO THE EDITOR.

Concerning the Stresses Due to Shrinkage in Reinforced Concrete.

Sir: In an article in Engineering News of March 15, 1906, on "The Design of Concrete-Steel Beams and Slabs," by Edward Godfrey, he says (first column, page 291):

> The fact that concrete in which steel is embedded has been stretched out in tests without cracking to elongations that would rupture plain concrete is evidence that the concrete in setting has shrunk, thus putting the steel under an initial compression which must be overcome before any stretch occurs in the concrete.

Now it seems to me that when the steel is put under compression by shrinking of the concrete, the latter is at the same time put under tension, and any further loading of the beam would all be carried by the concrete, so that it would have to take all the tension until it has stretched so far that all the initial compression has been taken off the steel. Edwin Squire.

Claremont, California, July 19, 1906.

Insurance Rates and the San Francisco Fire.

Sir: On my way West, to spend a few weeks at this place, I stopped for several days at San Francisco, mainly for the purpose of personally inspecting and investigating the structural and fire-protection lessons of that great disaster. While these lessons are many and valuable, it is the question of modifying insurance rates in the interest of good engineering practice and sound finance of which I wish to write.

As the location and character of the business portion of the great American cities is becoming well fixed, as engineering knowledge and practice make fire-resisting construction definitely practicable, and as fire losses in this country are such an enormous drain upon our resources it would seem that the time has come when a definite movement toward systematically curtailing and preventing such losses should be taken. European cities have attained this object, and it is only a question of expense that prevents our cities from being equally immune from destructive fires. The average owner will save a few thousand dollars by substituting inadequate fireproofing for that which would really protect the steel frame in case of fire, taking the gambler's chance that such severe fire will not occur; or will similarly save expense by omitting the metal door and window frames and accompanying devices for securing protection against introduction of fire from the outside, because the extra cost is immediate, while the extra risk is uncertain; or will reject the legitimate precautions against spread of fire from floor to floor because the real advantage is somewhat obscurely present while the extra cost is glaringly apparent.

Is it not the case that insurance rates might well be modified, to more nearly harmonize with the risk? Should not a building of steel frame which is truly adequately fireproofed be a less risk and therefore require a smaller rate than one inadequately protected? Should not buildings planned to prevent the spread of interior fire, those planned to prevent introduction of fire, and those so built in contiguous, compact blocks (so mutually protecting each other) call for rapidly decreasing rates until in the last case the rate is very small indeed? This would leave the rates on combustible buildings relatively very high, as they should be, because the latter are the real menace and constitute the great hazard.

It was while scrutinizing the devastation at San Francisco that these considerations occurred to me, and I send this to you, to be used in whatever way may seem to be most likely to secure the adoption of the principles indicated.

I may also add that, in the rebuilding of San Francisco, there is offered an opportunity for applying advantageously the principles outlined. If you or the insurance people find it desirable, I can put you in communication with San Franciscans who would aid in any way possible.

Very truly yours,

J. L. Van Ornum.

435 South Lake Ave., Pasadena, Cal., July 19, 1906.

[Unquestionably the fire insurance companies will be forced to discriminate even more sharply than heretofore against bad and in favor of poor risks. Nothing else will prevent repetitions of such vast, needless fire losses as have occurred at Baltimore, San Francisco and elsewhere. That this is all too true is evidenced by the failure of Baltimore to profit by the lessons of its fire, and by the way in which San Francisco is following the example of Baltimore. The municipal authorities in each city have lacked the backbone necessary for the adoption and enforcement of needed rigid building ordinances, and many of those rebuilding have and are taking advantage of this lack, at great peril to themselves and their fellow-citizens. We are well aware that the exigencies of the case, which in San Francisco are even greater than they were in Baltimore, make it very difficult to avoid improper rebuilding. But, to come back to and expand the suggestion of our correspondent, the insurance companies simply cannot stand for the continuation of such risks, and will be bound to prevent, or at least reduce, them by increasing their rates.—Ed.]

The Earthquake Damage to the Stanford University Buildings.

Sir: On April 29, 1906, at your telegraphed request, I sent you a short report on the earthquake damages in San Francisco and vicinity. This report appeared in your issue of May 10, 1906, and necessarily dealt largely with injuries to the Stanford University buildings, these being the most important instances of damage by earthquake not complicated by damage from fire.

While going into very little detail and speaking in general terms only, my expressed opinion was that the damage to such Stanford University buildings as were badly injured was due to poor design and poor construction, rather than to the severity of the shock; and that well designed and well constructed buildings, either at Stanford or elsewhere, were but little injured by the earthquake. This is still my belief and, with hardly an exception, that of every engineer or architect of whom I have heard who has had an opportunity to examine buildings injured by the earthquake of April 18.

My attention has been called to a letter by Mr. Chas. Ed. Hodges (for many years past and until about the end of June, when he resigned, Resident Architect for the Board of Trustees of Stanford University) in your issue of June 7, 1906, commenting on my letter of April 29, and saying he "would like to contradict some of the misstatements contained therein," and that he "fails to comprehend the motive of your correspondent, living in this community, who sent out such an unfair statement." My present letter is in reply to his.

In answer to Mr. Hodges' charge that my letter contained misstatements, he is no doubt correct in a minor way. Generalizations are always dangerous and in dividing the buildings at Stanford University into two general classes, good and bad, some injuries to good buildings were unmentioned and also some good points in those which failed. My conclusions, however, are true, with only such few exceptions as are usually linked with a general statement. For this I have not only my own observation and judgment, but the expressed opinions of other engineers, also of architects and of contractors and builders.

As to my motive for "such an unfair statement," my only motive for the statement (which was not unfair) was to give the readers of Engineering News some general information on the effect of the earthquake of April 18 on human constructions. This is a more important question than may at first appear. If the shock was so severe that human constructions could not have been made of sufficient strength to withstand it, the rebuilding of San Francisco would evidently be a fool-hardy act and a mere gambling on the length of time which may ensue before a similar shock may recur. Or it might be economically inadvisable to rebuild even if such constructions as are already accepted as good by engineers and most architects could not withstand such a shock. Fortunately for California, however, neither is the case—and good design and construction, as generally understood among engineers, has shown itself sufficient to withstand the shock of the late earthquake with but little resulting injury. Claims to the contrary are not well founded and (even though well meant) can result only in harm to San Francisco.

A valuable report on the earthquake damages at Stanford University buildings has so far failed of publicity. Shortly after the earthquake a commission of three was appointed by the Board of Trustees to report on the injuries to buildings, the appointees being H. A. Schulze, Architect; J. D. Galloway, Civil and Structural Engineer, and J. B. Leonard, Civil Engineer and specialist in reinforced concrete. Mr. Schulze is a member of the American Institute of Architects and president of its local association, and is well and favorably known in San Francisco. Mr. Galloway is a member of the American Society of Civil Engineers and Chairman of the Committee on Buildings appointed by its local association just after the earthquake, and was also the designer of the steel skeletons of some of the largest and best of the tall office buildings of San Francisco. Mr. Leonard is well known as having had a wide and varied experience in reinforced concrete construction.

After much time spent in investigating the buildings, this able commission presented its report about the end of June. It is greatly to be hoped this report will be made public, as it would undoubtedly be of great value to the professions of architecture and engineering and its conclusions should be of service in planning the reconstruction of San Francisco. Its publication would remove from the field of conjecture the exact damage done by the earthquake to the University buildings and should decide the advisability of the use of certain details and forms of construction in earthquake countries. It is hoped that the Board of Trustees will see the advisability of publishing this report.

The repairs to the injured buildings are going on under a commission of three engineers, appointed by the Board of Trustees on June 29. The commission is composed of Professors C. D. Marx, in charge of the department of Civil Engineering, Chairman; W. F. Durand, in charge of the department of Mechanical Engineering, and C. B. Wing, Professor of Structural Engineering. Professor Wing is the executive member. This board has complete and independent charge of the work, its functions covering methods, purchase of plant and materials, fixing of rates and hiring of labor—and the complete execution and inspection of the work. The present scope of the work is (1) the repairing of all injured class-rooms and laboratories so that they may be again ready for use by the end of August, the beginning of the college year, and (2) the wrecking (or clearing up the ruins) of the several destroyed buildings—Library, Gymnasium, Museum, etc. As the latter must be done slowly and with a comparatively small force, its completion may require even a year. The work of this commission is already well under way, its force numbering about one hundred and fifty at the present time and constantly increasing. Very truly,

Edwin Duryea, Jr.

1243 Franklin St., San Francisco, Cal., July 18, 1906.

Notes and Queries.

Our attention has been called to the statement in the recent obituary notice of C. J. Ives that the Burlington, Cedar Rapids & Northern Ry. was absorbed by the Chicago, Burlington & Quincy Ry., while as a matter of fact it forms the Northern Division of the Chicago, Rock Island & Pacific Ry.

Referring to the Table of Weights of Lacing published in our issue of Aug. 2, 1906, p. 122, Mr. C. T. Lewis, of Chicago, who sent us the table for publication, corrects our statement that the table was computed by him, and says:

A copy of a table of weights of lacing was given to me by a fellow-draftsman about seven years ago. I revised and consolidated the matter and added the data given above the table of weights as published, the whole involving quite a little work.

It is not improbable that more than one draftsman or estimator has computed a similar table for his own use.

A Wilkinsburg inquirer asks us for

Some late data as to steam-consumption, per indicated or brake horse-power, of the best modern steam engines, either simple, compound or triple-expansion, with or without superheat.

The acceptance tests of the 7,500-HP. compound engines of the Interborough Rapid Transit Co. (58th St. powerhouse), at New York City, reported in our issue of Jan. 11, 1906, show a steam-consumption, with saturated steam, at approximately full load, of 11.95 lbs. per I. HP. hr. A much smaller compound, about 400-HP. capacity, using superheated steam, was tested in 1903 and is reported by Prof. D. S. Jacobus, Trans. Am. Soc. M. E., XXV. 264. It showed a water consumption of 9.56 lbs. per I. HP. at about full load. These are condensing engines. A considerable collection of figures on the subject is given in Kent's "Mechanical Engineer's Pocket Book," pp. 775 to 787.

REPORT ON WATER WASTE IN NEW YORK AND ITS REDUCTION BY METERS AND INSPECTION.

Another addition, and that a weighty one, has been made to the voluminous literature of water supply and water waste in New York City. For this the people of New York and all people interested in water waste prevention are indebted to the Merchants' Association of New York and to Mr. Jas. H. Fuertes, M. Am. Soc. C. E., of New York City. The organization named, many will remember, acting through its water supply committee, published a valuable report on the water-works problem of New York, a few years ago. The same committee, with changes in membership, and with Mr. Henry R. Towne, M. Am. Soc. M. E., as chairman, recently engaged Mr. Fuertes

to examine and report upon the probable extent of water waste in this city, practicable methods for controlling and reducing it, waste-reduction in other cities, the cost of general metering, and the financial saving resulting from utilizing the water now wasted.

In addition, Mr. Fuertes was asked to consider whether or not, in view of possible curtailment of water waste, the proposed new Catskill supply could be deferred.

The result of Mr. Fuertes' efforts, combined with a small amount of supplementary information, is an octavo volume of nearly three hundred pages. This volume is by far the most important monograph on water waste and its prevention that has been published for many years, if indeed it has ever been equalled. While directed primarily to the conditions and needs of New York City, it is by no means confined to that city in its data nor in the applicability of many of its conclusions. To the latter, in view of the size and character of the report, we must chiefly confine this article, except for the reprinting of a very useful table of per capita water consumption for various purposes and water unaccounted for in a large number of American and German cities. The summary of conclusions is as follows:

In Manhattan and the Bronx the amount of leakage and wastage effectively and quickly controllable probably did not average for the ten years prior to 1904 more than about 15% of the supply, and was largely confined to the fixtures and services of unmetered consumers.

The leakage from the street mains is relatively small in amount, and such as exists could not be stopped short of many years of costly work. Its complete stoppage, even if possible, would be of very little benefit as compared with the control of the leakage and wastage taking place from the fixtures on the premises of unmetered consumers.

Manhattan and the Bronx are at the present time not only using more water daily than can be safely depended

COMPARATIVE STATISTICS OF SEVERAL AMERICAN AND GERMAN CITIES,

Showing Particularly the Percentage of the Total Supply Not Accounted For. (By Meters on Consumers' Pipes and Careful Estimates of the Unmetered Waters.) Figures Given, Relating to Consumption of Water, Are, Unless Otherwise Noted, Per Capita, Per Diem.

City.	Year.	Gallons per capita, per day — Water taken by consumers: Manufacturing.	Water taken by consumers: Domestic.	Water taken by consumers: Total.	For public uses.	Not accounted for.	Total per capita, galls.	Per cent. not accounted for.	Supply.	Per cent. services metered.
Brockton	1898	3.4	14.4	17.8	2.4	10.9	31.1	35	Pumped	79
"	1899	4.0	15.0	19.0	2.9	11.5	33.4	35	.....	80
"	1900	4.5	15.0	19.5	2.9	10.8	33.2	32	.....	81
"	1901	4.5	15.6	20.1	3.0*	10.1	33.2	30	.....	83
"	1902	5.0	16.0	21.0	3.0*	12.0	36.0	33	.....	90
"	1903	5.5	16.6	22.1	3.0*	12.0	37.1	32	.....	90
"	1904	5.1	15.5	20.6	3.0*	13.3	36.9	36	.....	91
Boston	1880	25.0	30.0*	55.0	2.0	29.0	86.0	34	Gravity	..
"	1892	30.0	30.0*	60.0	3.0	32.0	95.0	34	.....	..
Cleveland	1904	40.0	26.0	66.0	10.0*	20.0	96.0	21	Pumped	49
Englewood	1888	...	...	...	...	...	...	52	Pumped	100
Fall River	1899	7.0	15.0	22.0	5.7	8.5	36.2	23	Pumped	93
"	1900	...	...	21.4	7.1	7.9	36.4	22	.....	94
"	1901	...	...	20.4	6.9	6.6	33.9	20	.....	95
"	1902	...	...	23.4	8.3	8.7	40.5	21	.....	95
Hackensack	1884	...	...	...	...	148.0†	308.0†	48	Pumped	100
"	1885	...	...	...	...	81.0†	238.0†	34	.....	100
"	1886	...	...	...	...	101.0†	256.0†	39	.....	100
"	1887	...	...	...	...	131.0†	313.0†	42	.....	100
"	1888	(½ Yr.)	...	...	...	173.0†	446.0†	39	.....	100
Hartford	1904	3.0*	30.0	33.0	5.0*	24.0	62.0	39	Gravity	99
Harrisburg	1891	33.0	30.0*	63.0	5.0*	54.0	122.0	44	Pumped	‡
"	1892	43.0	30.0*	73.0	5.0*	44.0	122.0	36	.....	‡
"	1893	42.0	30.0*	72.0	5.0*	44.0	121.0	36	.....	‡
"	1894	37.0	30.0*	67.0	5.0*	36.0	108.0	33	.....	‡
"	1895	44.0	30.0*	74.0	5.0*	40.0	119.0	34	.....	‡
"	1896	42.0	30.0*	72.0	5.0*	30.0	107.0	28	.....	‡
"	1897	47.0	30.0*	77.0	5.0*	25.0	107.0	23	.....	‡
"	1898	49.0	30.0*	79.0	5.0*	28.0	112.0	25	.....	‡
"	1899	65.0	30.0*	95.0	5.0*	22.0	122.0	18	.....	‡
"	1900	73.0	30.0*	103.0	5.0*	25.0	133.0	19	.....	‡
"	1901	80.0	30.0*	110.0	5.0*	20.0	135.0	15	.....	‡
"	1902	79.0	30.0*	109.0	5.0*	20.0	134.0	15	.....	‡
"	1903	78.0	30.0*	108.0	5.0*	30.0	143.0	21	.....	‡
"	1904	81.0	30.0*	111.0	5.0*	30.0	146.0	21	.....	‡
Lawrence	1902	11.0	15.0	26.0	5.0*	23.0	54.0	42	Pumped	84
"	1903	10.0	15.0	25.0	5.0*	12.0	42.0	29	.....	86
"	1904	8.0	17.0	25.0	5.0*	12.0	42.0	29	.....	87
Milwaukee	1904	45.0	25.0*	70.0	5.0*	14.0	89.0	16	Pumped	79
Ridgefield	1886	...	...	...	...	62.0†	175.0†	35	Pumped	100
"	1887	...	...	...	...	10.0†	133.0†	8	.....	100
"	1888	(½ Yr.)	...	...	...	24.0†	181.0†	12	.....	100
Madison	1897	...	...	14.0	13.0*	17.0	44.0	39	Pumped	89
"	1898	...	...	14.0	13.0*	13.0	40.0	32	.....	92
"	1899	...	...	14.0	13.0*	15.0	42.0	36	.....	92
"	1900	...	...	15.0	13.0*	15.0	43.0	35	.....	94
"	1901	...	...	20.0	13.0*	17.0	50.0	34	.....	95
"	1902	...	...	21.0	13.0*	12.0	46.0	26	.....	95
"	1903	...	...	21.0	13.0*	22.0	56.0	39	.....	96
"	1904	...	...	21.0	13.0*	37.0	71.0	52	.....	96
Syracuse	1904	39.3	31.0	70.3	18.0	20.0	108.3	19	Gravity	72
Taunton	1898	13.0	18.3	31.3	3.0*	14.3	48.6	29	Pumped	38
"	1899	13.0	22.5	35.5	3.0*	15.2	53.7	28	.....	40
"	1900	14.8	20.5	35.3	3.0*	23.7	62.0	38	.....	41
"	1901	14.6	22.5	37.1	3.0*	24.9	65.0	38	.....	42
"	1902	15.2	20.5	35.7	3.0*	15.3	54.0	28	.....	43
"	1903	16.6	21.0	37.6	3.0*	13.4	54.0	25	.....	45
"	1904	14.7	21.5	38.2	3.0*	24.8	64.0	39	.....	45
Ware	1902	...	...	...	...	17.0	44.0	39	Pumped	100
Wellesley	1901	0.3	24.3	24.6	2.8	20.6	48.0	43	Pumped	100
"	1902	0.3	25.4	25.7	2.2	22.1	50.0	44	.....	100
"	1903	0.4	28.2	28.6	3.2	23.2	55.0	42	.....	100
"	1904	0.4	28.6	29.0	2.5	23.5	55.0	43	.....	100
W. Orange	1905	..	..	...	...	...	...	20	Gravity	100
Woonsocket	1902	...	...	...	...	7.0	29.0	24	Pumped	87
Worcester	1902	...	...	...	...	29.0	68.0	42	Gravity	95
Yonkers	1900	13.0	18.0	40.0	0.4	37.6	78.0	48	Pumped	98
"	1901	16.0	19.0	39.6	3.0	41.4	84.0	49	.....	94
"	1902	22.0	19.0	46.0	3.0	40.0	89.0	45	.....	94
"	1903	22.0	20.0	49.0	2.0	37.0	88.0	42	.....	99
"	1904	24.0	20.0	51.5	2.0	40.5	94.0	43	.....	100
Bamberg	1895	...	...	9.6	3.7	2.0	15.3	13	Pumped	71
"	1896	...	...	9.2	3.7	2.4	15.3	16	.....	73
"	1897	...	...	9.8	3.3	2.7	15.8	17	.....	78
Berlin	1895	...	...	15.3	1.8	.9	18.0	5	Pumped	100
"	1896	...	...	15.0	1.6	1.6	18.2	9	.....	100
Eisenach	1895	...	...	6.7	6.1	1.5	14.3	11	Gravity	99
"	1896	...	...	8.4	5.3	1.5	15.2	10	.....	99
"	1897	...	...	8.3	4.9	1.1	14.3	9	.....	99
"	1898	...	...	8.2	3.7	1.3	13.2	10	.....	99
"	1899	...	...	9.5	3.4	1.4	14.3	9	.....	99
Hannover	1894	...	...	10.8	2.8	2.2	15.8	14	Pumped	100
"	1895	...	...	16.9	4.5	2.9	24.3	12	.....	100
"	1896	...	...	15.8	2.0	3.4	21.2	16	.....	100
Rudolstadt	1898	...	...	9.9	0.2	4.2	14.3	29	Pumped	100
"	1899	...	...	10.4	0.3	4.4	15.1	29	.....	100
Stralsund	1896	...	...	12.9	1.6	6.9	21.4	32	.....	100
Breslau	1889	...	...	13.5	2.5	3.5	19.5	18	Pumped	100
"	1890	...	...	14.0	2.6	3.7	20.3	18	.....	100
"	1891	...	...	13.9	2.4	3.8	20.1	19	.....	100
"	1892	...	...	13.9	2.8	5.0	21.7	23	.....	100
"	1893	...	...	14.7	2.6	4.6	21.9	21	.....	100
"	1894	...	...	14.7	2.9	4.6	22.2	21	.....	100
"	1895	...	...	14.5	2.8	4.4	21.7	20	.....	100
"	1896	...	...	17.4	1.9	3.9	23.2	17	.....	100
Darmstadt	1890	...	...	...	...	...	...	12	.....	100
"	1891	...	...	11.2	0.7	1.6	13.5	11	Pumped	100
"	1892	...	...	12.5	0.6	1.7	14.8	16	.....	100
"	1893	...	...	14.6	0.5	2.9	18.0	16	.....	100
"	1894	...	...	16.0	0.6	3.2	19.8	21	.....	100
"	1895	...	...	14.5	0.5	2.4	17.4	13	.....	100
"	1896	...	...	14.8	1.6	3.1	19.5	16	.....	100
"	1897	...	...	15.2	1.6	3.5	20.3	17	.....	100
"	1898	...	...	17.5	0.8	2.0	20.3	10	.....	100
"	1899	...	...	18.8	0.4	2.2	21.4	10	.....	100
"	1900	...	...	18.8	0.4	2.2	21.4	10	.....	100
Gotha	1890	...	...	8.2	2.8	4.0	15.0	26	.....	100
"	1891	...	...	7.4	2.5	3.3	13.2	25	Gravity	100
"	1892	...	...	6.1	2.1	3.1	11.3	28	.....	100
"	1893	...	...	5.3	1.8	2.7	9.8	28	.....	100
"	1894	...	...	6.6	2.4	3.6	12.7	29	.....	100
"	1895	...	...	6.6	2.4	3.6	12.7	30	.....	100
"	1896	...	...	5.3	1.2	2.5	9.0	28	.....	100
"	1897	...	...	7.4	1.7	2.6	11.6	26	.....	100
"	1898	...	...	8.4	2.1	3.5	14.0	25	.....	100
"	1899	...	...	6.4	1.6	2.3	10.3	22	.....	100
Magdeburg	1891	...	...	10.0	1.5	3.0	23.5	13	Pumped	100
"	1892	...	...	19.4	1.6	2.8	23.8	11	.....	100
"	1893	...	...	20.2	1.8	3.6	25.6	14	.....	100
"	1894	...	...	20.2	1.6	4.6	26.4	17	.....	100
"	1895	...	...	18.3	1.2	3.5	23.0	15	.....	100
"	1896	...	...	19.7	1.3	3.8	24.8	15	.....	100
Mainz	1895	...	...	7.4	1.9	1.0	10.3	9	Pumped	100
"	1896	...	...	8.7	2.6	0.6	11.9	5	.....	100
"	1897	...	...	9.4	1.8	0.9	12.1	7	.....	100

COMPARATIVE STATISTICS OF SEVERAL AMERICAN AND GERMAN CITIES.—Continued.

Mainz	1898	...	...	9.9	1.7	0.8	12.4	6	.....	100
"	1900	...	...	10.3	3.6	3.3	17.2	19	.....	100
Mannheim	1892	...	...	12.2	3.3	2.7	18.2	15	Pumped	100
"	1893	...	...	13.7	4.2	2.9	20.6	14	.....	100
"	1894	...	...	12.3	3.8	2.4	18.5	13	.....	100
"	1895	...	...	13.5	3.8	2.5	19.8	13	.....	100
"	1896	...	...	14.2	4.0	1.9	20.1	10	.....	100
"	1897	...	...	15.0	3.6	2.2	20.8	10	.....	100
"	1898	...	...	16.4	3.8	2.0	22.2	9	.....	100
"	1899	...	...	16.7	3.3	2.7	22.7	12	.....	100
"	1900	...	...	16.7	2.4	3.4	22.5	15	.....	100
Potsdam	1892	...	...	3.2	0.4	0.9	4.5	19	.....	100
"	1892	...	...	13.6	1.9	1.7	17.2	10	.....	100
"	1893	...	...	12.2	2.4	2.8	17.4	16	.....	100
"	1894	...	...	14.2	2.2	2.1	18.5	11	.....	100
"	1895	...	...	12.6	1.0	0.9	14.5	6	.....	100
"	1896	...	...	10.0	1.1	1.6	12.7	12	.....	100
Quedlinburg	1888	...	...	3.4	0.8	0.6	4.8	12	Pumped	100
"	1889	...	...	3.8	0.8	0.9	5.5	16	.....	100
"	1891	...	...	5.2	1.2	1.0	7.4	14	.....	100
"	1892	...	...	5.3	1.4	3.3	10.0	33	.....	100
"	1893	...	...	6.1	1.2	2.7	10.0	27	.....	100
"	1894	...	...	5.3	0.8	1.3	7.4	17	.....	100
"	1895	...	...	5.5	0.6	1.5	7.6	20	.....	100
"	1896	...	...	5.7	0.7	1.8	8.2	22	.....	100
Strassburg	1896	...	...	10.1	8.8	2.2	21.1	10	Pumped	100
"	1897	...	...	10.2	6.8	2.0	19.0	16	.....	100
"	1898	...	...	11.1	7.8	2.2	21.1	10	.....	100
"	1899	...	...	12.3	9.0	2.4	23.7	10	.....	100
"	1900	...	...	13.2	11.2	2.8	27.2	10	.....	100
Weimar	1890	...	...	9.6	1.4	2.7	13.7	20	Pumped	100
"	1891	...	...	9.9	2.3	2.0	14.2	14	.....	100
"	1892	...	...	10.0	1.8	3.2	15.0	21	.....	100
"	1893	...	...	12.5	1.7	2.4	16.6	15	.....	100
"	1894	...	...	11.7	1.7	3.5	16.9	21	.....	100
"	1895	...	...	10.5	1.5	2.2	14.2	15	.....	100
"	1896	...	...	10.6	1.4	2.5	14.5	17	.....	100
"	1897	...	...	9.5	1.2	3.8	14.5	26	.....	100
Worms	1897	...	...	16.7	2.1	2.3	21.1	11	.....	100
"	1898	...	...	19.2	2.5	3.6	25.3	14	.....	100
"	1899	...	...	21.2	3.8	2.2	27.2	8	.....	100
"	1900	...	...	24.2	2.6	2.0	28.8	7	.....	100

Data for the American cities taken from the Annual Reports of the Water Boards of the different cities.
Data for the German cities from "Die Städtische Wasserversorgung in Deutschen Reiche sowie in Einigen Nachbarländern." E. Grahn, 1902.
*Figures starred (*) are estimates by J. H. F., based on data given in reports, in most instances, or on such descriptions of conditions and uses as would warrant an approximate estimate.
†Figures marked with a dagger refer to consumption per water taker; not per capita.
‡All manufacturing and two-third domestic.

upon from the Croton and Bronx watersheds, with the present available storage, but are actually using within about 17% of the greatest amount that could be continuously obtained if the reservoirs were large enough to hold back for use the entire stream flow, allowing no water to waste over the dams during pretty nearly a generation. (With meteorological conditions identical with those which have prevailed since 1879.)

Only 17% more water could be continuously had from the Croton watershed, no matter how much storage were provided, for the reason that the city is now using within 17% of the average flow of the Croton River. To get this last 17% the storage would have to be about 2½ times as great as the combined capacities of all the existing reservoirs, lakes and ponds now on the watershed. Such storage cannot be had; therefore New York must go to other watersheds for more water.

If the storage in the Croton watershed is increased materially beyond the present amount it will be at the risk of spoiling the water.

During recent years the relative amount of rain falling in the different seasons has been favorable to large summer stream flows in the Croton watershed. If in any year since 1901 the same total amount of rain had been distributed differently, that is: if more had fallen in the summer and less in the spring, under conditions no less extreme than have frequently prevailed in the past, the water department would have been compelled to partially shut off the supply for several months at a time to avoid emptying the storage reservoirs. Cutting off a part of the supply would reduce the pressures all over the city with the added risks of general conflagrations (due to the inability, through lack of water, to control small fires).

The flow of the Croton River has been above the average for several years. It must soon, therefore, fall below.

It requires no exaggeration to portray the dangers of the situation when it is realized that the amount of water the city is using from the Croton watershed is within 17% of the average flow of the Croton River, and that the flow of this river, as known by its past records, may possibly fall for an entire year to an amount 40% below the average.

With the greatest amount of waste and leak reduction possible of practical accomplishment during the coming years, and with the construction of the proposed Cross River reservoir and all other emergency reservoirs that can be built in the Croton watershed, the city will not be out of danger of a water famine until the new supply is made available. The construction of the first installment of the new works should therefore be started immediately and should be pushed to completion as rapidly as possible.

In order to carry the city through the intervening years that must elapse before the new supply can be built, with a reasonable assurance of averting the probable certainty of a short supply (if the lessons to be learned from the record of the flow of the Croton River for the past 38 years can be depended on as an indication of future conditions), comprehensive steps to stop leakage and wastage must be taken immediately and must be maintained without relaxation.

Leakage and wastage can be controlled by house-to-house inspections, or by inspections in conjunction with partial metering, or by universal metering.

The control of leakage and wastage by house-to-house inspections will be incomplete, as, in order to have been detected, leaks must have already existed. Relatively complete control of these losses can only be had by universal metering.

The metering of all domestic consumers will prove a very profitable investment in New York City by postponing for from 12 to 15 years the necessity of building the second 250,000,000-gal. installment of the new additional supply, with a net saving over the cost of metering of about $2,000,000 per year for that period.

As it is imperative that as great a reduction as possible be immediately secured in leakage and wastage, the conditions demand:

(1) The organization and placing in effect at once of a comprehensive system of house-to-house inspections, coupled with examinations of the flows in the street mains (for the purpose of locating quickly the most serious losses) to carry the city through until the question of final control of wastage can be settled.

(2) There must be secured to the city the right, which it does not now possess, to place meters on the services of domestic consumers.

The foregoing conclusions are supported by lengthy general discussions of the points involved, and these, in turn, by a number of appendixes. One of the latter reviews waste prevention measures in many American and German cities, and is a most convenient and valuable feature of the report.

In discussing the low water consumption of German cities the author points out that this is largely due to the fact that the people abroad are mostly housed in flats, have few fixtures, and short lengths of distribution and service pipe, few valves and hydrants, etc., to give rise to leaks. In Berlin 70 people, as compared with 5 in Detroit, are supplied from one service pipe, and there are relatively few private bath tubs in Berlin. In European cities generally there are very few or no set washstands and laundry tubs supplied with hot and cold water. If, then, the per capita waste of water is smaller in German than in American cities "it is because the opportunities for waste are smaller." The American *consumes and uses* more water than the European, but with the American

the waste, or, to express it more properly, the lost water, is not chargeable to the wastefulness of the individual, but to the fact that in our cities the opportunities for leakage from mains and service pipes and from faulty plumbing, old, worn-out faucets, ball-cocks, etc., are multiplied many fold.

Nevertheless, the German cities, starting with a consumption under schedule or fixture rates that was small when compared with American figures, have greatly reduced their consumption by the introduction of meters.

Summing up his review of the experience of American and German cities Mr. Fuertes says:

(1) Wastage and leakage can be quickly stopped and permanently suppressed without depriving any citizen of the use of as much water as that to which he has been accustomed. That the question of the suppression of the greater part of the wastage is to all intents and purposes merely a hunt for leaks followed by the watching of the different consumers and the insisting that they keep fixtures from leaking.

(2) That sale of water by measure has no tendency to restrict the use of water, but does notify the owner when the leakage from the faucets and other fixtures, is serious enough to require attention. That wastage from domestic premises is rare, but that leakage is prevalent. That tenants do not wilfully waste water, and that the blame for the present conditions in New York rests not upon the hundreds of thousands of users of water, but upon the relatively few owners who neglect to keep their plumbing in order as required by the city ordinances. That the responsibility for this state of affairs rests primarily with the system under which the water is sold. That the sale of water by meter does not work a hardship on owners of property rented to tenants; in practically all cities, from Berlin to Asbury Park, the water taxes are liens on the property, and yet, in no city, where the system has been adopted permanently, and where the rates have been properly adjusted, would either the water-works managers or the inhabitants of the city go back to the old system.

To support his conclusion that, even if all services were metered, New York City would still be unable to account for 25% of the water supplied to it, Mr. Fuertes presents a table in his report, which, as already mentioned, we reprint herewith. In practically all the foreign cities included in the table allowances have been made for pump slippage and for under-registration of meters.

Available cost data from other cities where large meter installations have been made, lead Mr. Fuertes to believe that, all sizes considered, the average cost of providing and setting meters in New York would be $15 The annual charge per meter is figured as follows:

Interest on cost of meter, $15, at 3%	$0.45
Depreciation, life 20 years	.75
Maintenance, renewals, testing, repairs, etc., $15, at 3⅓%	.50
Reading meters, sending out bills, etc	.66
Total cost per year per meter	$2.36

Mr. Fuertes then says:

If Brooklyn, Queens and Richmond, as well as Manhattan and the Bronx, are to be supplied from the new works, and if no method is put in force for the control of wastage, the limit of the capacity of the first installment of the new proposed Catskill works will have been reached by 1918, whereas if the city is put on the meter basis the additional supply will not be needed until twelve years later.

The cost of the second installment of the additional works will be $51,400,000 if the water-sheds on the east side of the Hudson are developed to 260,000,000 gals. daily capacity, to include all the water obtainable without pumping from Fishkill Creek, Wappinger's Creek and Jansens Kill.

During these twelve years, with no meters in service, the annual cost will have been as follows:

Interest on $51,400,000, at 3%	$1,542,000
Sinking fund to retire bonds in 40 years—$51,400,000, at 1.37%	700,000
Depreciation on gates, valves, pipes, filters, etc., at 6%	310,000
Ordinary repairs, keepers' wages, sanitary policing, laboratory, and accounting	90,000
Cost of filtering wasted water, 150,000,000 gals. daily, at $3	165,000
Total annual expense	$2,807,000

With this should be compared the cost of metering during the same period.

The average number of services in use for the period, at a somewhat less favorable ratio than obtains to-day, would be:

Average population during period, 4,800,000 ÷ average number of persons per service, 16, = 300,000.

With meter on every service the cost per year would be; 300,000 meters, at $2.36 per meter per year for meters, repairs, renewals, interest, reading, sending out bills, etc	$708,000
Difference, representing excess cost per year, due to waste and leakage	$2,099,000
Or, for the 12 years	25,188,000

(ABOUT HALF ENOUGH MONEY TO BUILD THE ADDITIONAL WORKS WHEN THEY BECOME NECESSARY.)

If Brooklyn, Queens and Richmond are supplied from other sources and only Manhattan and the Bronx from the proposed new Catskill works, the comparison is still more favorable, as the construction of the second installment of the works could be deferred about 15 years, resulting in a cash saving to the city, after paying for the meters, their repairs, testing, renewals, maintenance, reading and sending out bills, etc., of about $32,000,000, or almost two-thirds of the amount necessary to build the second installment of the new works for a yield of 260,000,000 gals. daily.

COLLAPSE OF THE AMSDEN BLOCK, SOUTH FRAMINGHAM, MASS.

By C. M. Saville,* M. Am. Soc. C. E.

At about 3.30 p. m. July 23, a building under construction in South Framingham, Mass., collapsed in part, burying a number of the workingmen in its ruin, killing or fatally injuring 12 men and totally ruining the building itself. The building, which was 3½ stories in height, was begun last January and was intended to be one of the finest in the town. It had 125 ft. front on Concord St. and was 75 ft. deep. The owner was George M. Amsden, and the contractor Andrew Jensen. From inquiries at the site of the disaster it appears that the foundation walls, foundations for the columns carrying the floors and the floors themselves were made of concrete of the proportions 1 cement, 3 sand, 5 or 6 clean gravel. The columns were of cast iron. The walls of the superstructure were of hollow concrete blocks made on the premises, composed of 1 part cement and 3 parts sand. The roof was of concrete and was to be covered with a preparation of asphalt and gravel.

From the paper cement bags on the work, both empty and filled, it appeared that the cement used was either of the Giant or Alpha brand.

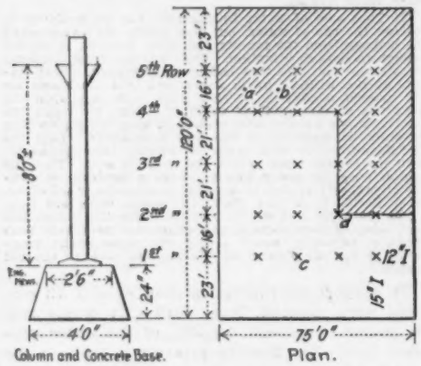

Fig. 1. Plan of the Amsden Building, South Framingham, Mass.; and Sketch of Column and Column Base.

Cross-hatching indicates portion which did not collapse.
Points a and b denote location of 4 × 6-in. upright timbers shown in view Fig. 2. These timbers were placed several days before the collapse, on account of large cracks which opened in the walls in the first story.
Point c is location of column over which a large crack appeared in the partition wall, which was being built just before the collapse.
All columns in first row settled 4 to 6 ft., depending on the condition of the excavation in the cellar bottom.
Columns were cast-iron, 7 ins. outside diameter, 4½ ins. inside diameter, and rested on cast-iron bed plates 20 ins. square, 1 in. thick at edge and 2½ ins. thick at center.

*With French & Bryant, Boston, Mass.

The sand was taken entirely from the excavation for the cellar and appears to be clean and sharp, but mostly too fine for concrete work. The gravel is said to have been brought into the work in bags and was very clean, practically washed gravel.

When the building collapsed the north wall and a portion of the west wall fronting on Concord St. fell inwards and floors and walls were carried directly to the cellar, only being stopped when reaching the ground. The cellar walls in the foundation, 1.75 ft. thick, were found intact; the easterly side wall did not fall in even when the floor girders were pulled from it. The walls were about 1.33 ft. thick for the first story and about 1 ft. for the remainder. As stated above, the walls were of hollow concrete blocks which were said to have been 2½ ft. long, and some similar blocks tested at the Watertown Arsenal recently are said to have had a crushing strength of over 31 tons. The fact that the walls stood seems to relieve them of any burden in the affair. From conversation with several persons on the work it appears that only on the portion that collapsed had the roof been placed, and that this was quite a heavy structure.

The three floors which collapsed were of 1-3-5 or 6 concrete reinforced with Clinton wire cloth. This was the only reinforcement used throughout the building, so far as the writer could ascertain, and the severe and unlooked-for strains which it bore speak most highly for its efficiency. In Fig. 3 one of the floor beams [marked by an arrow] is seen twisted completely off its bearings by the weight of the concrete mass pulling on the reinforcement. When it is realized that this pull not only meant turning the girder but also twisting the 2 in. × ½-in. strap that fastened the girders together around the columns, some idea of the strength is apparent.

All of the columns in row 1, Fig. 1, settled and the Town Committee to-day [Aug. 6] is digging them out for the purpose of ascertaining the cause of the disaster. It has been reported that probably quicksand under the column footings was the cause of the disaster. From an inspection of the ground [Aug. 6] there is no appearance of quicksand, although the ground water level is apparently up to the top of the concrete foundations under the piers. The concrete in the walls is said to be of the same mixture as that under the columns, but, while the former is hard and firm and rings true to a blow, that in the column foundations is soft and easily crumbled. There is no metal reinforcement in these foundation blocks so far as the writer could see or was able to learn. The cast-iron bed plate under each column in this row [No. 1] is split and broken into numerous pieces, as is also the concrete block. The columns themselves are all whole and appear to have been driven down through the cast-iron bed plates and through the concrete blocks. I am informed that where excavated these foundation blocks seem firm and hard on the outside, but when the outer shell is broken the inside is soft enough to be readily scraped out with the shovel. From appearances it would seem that the additional weight of the roof on the portion that collapsed may have been just sufficient to crush the soft concrete in the foundation; the weight then resting entirely on the bed plates, these being and the columns were driven down through the concrete block into the earth, carrying with them the floors and roof. Later information may, however, show other causes.

So far as the writer could learn from the tangle of rubbish, the floors were all built after the same general plan, 15-in. I-beams on the long spans and 12-in. I-beams in others, with 9-in. beams in the roof. If the span was 15 ft. there would be an area of 225 sq. ft. on each floor and on the roof supported by each column. The floors were 5½ ins. thick and the roof 4½ ins. Assuming that the concrete weighs 146 lbs. per cu. ft., we have,

Floors, 225 × 3 × .46 × 146 =	45,333 lbs.		
Roof, 225 × .37 × 146 =	12,154		
Concrete	57,487 lbs.	=	28.75 tons.
15-in. I 19½ ft. long =	1,400		
12-in. I 15 ft. long =	750		
	2,150	=	1.07
Total	59,637 lbs.	=	29.82

The bottom of the concrete foundation was 16 sq. ft., so that there was less than 2 tons per sq. ft. for the soil to carry (Sand; for clean, dry sand Baker gives from 2 to 4 tons), leaving a very small factor of safety for local conditions here. But so far as was apparent the concrete blocks had not settled. The top of the concrete

Fig. 2.

Fig. 3.

Fig. 4.

FIGS. 2, 3 AND 4. THREE VIEWS IN COLLAPSED AMSDEN BUILDING, SOUTH FRAMINGHAM, MASS.

foundation was 30 ins. square, and these blocks were put in sometime in April. There appears, therefore, to be sufficient size in the concrete base to bear the load, although as the ground was very wet and as the building was being erected as a rush job it would have been on the side of safety to have put reinforcement in these blocks. In Fig. 4 under the arrow is seen one of the columns [d in Fig. 1] which sunk 18 ins.

One thing that may have saved the portion of the building now standing is the fact that the partitions were up in this portion and possibly stiffened it so that it bore the strain. It is well known that there was the greatest haste used to get this building up in order to get possible tenants from other localities. To this fact and the further fact that there was no building inspection here is probably due any lack of carefulness regarding proportions of ingredients or of ordinary care and foresight in construction work. Apparently the cement and concrete had not set sufficiently to bear the strain if the proportions as stated above were used.

A LEGAL DECISION INVOLVING THE PAYMENT OF A LARGE SUM FOR RAILROAD OVERHAUL.

A case which turned on the question of whether a contractor may receive the same compensation for overhaul carried in standard gage cars as in narrow gage cars, nothing in the specifications or contract to the contrary has recently been decided in favor of the contractor. The decision, which was handed down in the New York Supreme Court by Judge Alton B. Parker as referee, awarded to Charles Sundstrom and Frank M. Stratton a judgment against the Delaware & Hudson Co. for about $951,000 plus interest and the costs and expenses of the case.

In August, 1902, the railroad company invited bids for the work of reconstructing the Chateaugay Railroad, which was at that time narrow gage; it connects at Plattsburg with the Delaware & Hudson Ry. and runs to Lake Placid. From Plattsburg to Cadyville and from Saranac Lake to Lake Placid, the road was both standard and narrow gage, a third rail having been laid; the intervening portion, from Cadyville to Saranac Lake, was narrow gage only. The total length was 83 miles, including many curves and steep grades. The extent of the work was not yet fully determined at the time bids were invited, but as decided upon about a year later, involved, besides an extension of 2 or 3 miles at the eastern end, 41 miles of reconstructed standard gage road on the old roadbed, and the remaining distance of new roadbed. In adapting the old roadbed to the new, the curves were to be lessened, the banks widened and portions of the roadbed raised. The specifications for this work, as prepared by the chief engineer of the company, contained a clause defining excavation and overhaul, which formed the basis of the subsequent controversy. This clause is as follows:

> The price paid for "excavation" in all of the several classes thereof, will be understood to cover and pay for the entire expense of its removal by any method whatever, including loading, unloading, transporting and depositing, in the manner prescribed in the specifications, in the places designated by the engineer; provided the extreme haul of the material so transported does not exceed three thousand (3,000) feet, and beyond that distance the price named in the contract per cubic yard per one hundred (100) feet will be allowed and paid for such overhaul.

Under these specifications, Sundstrom & Stratton, on Aug. 26, 1902, bid 28 cts. per cu. yd. for excavation and 1 ct. per cu. yd. for overhaul. This bid was acceptable to the railroad company, provided Sundstrom & Stratton would enter into an agreement to complete the work by July 15 following, under a penalty of $100 for each day thereafter that the completion of the work might require. As an inducement for the contractors to enter into the contract and attempt its execution, the Delaware & Hudson Co. offered to allow for excavation 34 cts. instead of 28 cts. This proposition Sundstrom & Stratton accepted, and immediately engaged upon the work. A written agreement was executed in January, 1903, but was dated Aug. 26, 1902.

As the work progressed, however, a change in the gage of the railroad enabled the contractors to use larger cars for overhauling. The railroad company subsequently refused to pay for any overhaul not made in narrow gage cars, claiming that before the contract was executed it was expected that all the hauling would be done in narrow gage cars. Consequently, the railroad company in its monthly settlements paid only for such overhaul as was made in narrow gage cars. The contractors demanded payment for the entire amount.

The suit brought by the contractors against the railroad company involved another controversy, as to the classification of the excavation, but as this does not concern the main question, that of overhaul, it need not be considered here, save to mention incidentally that the testimony of the resident engineers who acted as inspectors for the railroad company was accepted in preference to that of engineers who inspected the work when completed and prepared estimates as to the amounts of solid and loose rock excavated. As to the question of overhaul, however, the referee decided that, under the clause of the specifications quoted above, there could be no doubt as to the meaning of the mutual agreement. To quote from the decision of the referee:

> Whether the contract was more favorable to plaintiffs than it ought to have been, in respect to the matter of overhaul; whether the defendant or its officers, or its engineer, had in mind, in agreeing to accept plaintiffs' bid on the subject of overhaul, that the dirt would all have to be hauled in narrow-gage cars, is of no importance in determining the rights of the parties under this contract. The written agreement is, in law, the repository of the real agreement of the parties. All prior engagements are deemed to be merged into it. And hence it follows that the evidence introduced tending to show that the representatives of the defendant at least expected only to pay for the material hauled in narrow-gage cars, can have no weight in the direction of giving to this contract a construction other than that which its language clearly and precisely imports. And it imports, as it seems to me, plainly and distinctly, that all material hauled over 3,000 ft. by direction of the engineer in charge, is to be paid for as overhaul, no matter how it may be hauled, whether in narrow-gage or standard-gage cars.

The total amount of overhaul was 646,518 cu. yds., for which the contractors claimed $1,794,977.75. Part of this work, however, was done after July 15, 1903, under different arrangements; i. e., it was explicitly stipulated by the railroad company that there should be no compensation for overhaul in standard gage cars. Consequently claim for overhaul under this new agreement was disallowed by the referee.

The chief engineer for the Delaware & Hudson Co. is Mr. James McMartin. To Mr. Wm. R. Hill, M. Am. Soc. C. E., chief witness for Sundstrom & Stratton as engineering expert, and to Mr. Thomas Watts, of Middletown, N. Y., attorney for the same company, who provided a copy of the referee's decision, we are indebted for the above information.

THE PERKIN JUBILEE OF THE COAL TAR INDUSTRY, commemorating the fiftieth anniversary of the epoch-making discovery by Dr. William Henry Perkin, of the dyestuff "Mauve," was celebrated in England July 26 and 27. An appeal for subscriptions has been made by the English committee for the following purposes: to present to Dr. Perkin for his lifetime an oil portrait of himself, which at his death will become the property of the nation; to have executed a marble bust of Dr. Perkin, to be placed in the rooms of the Chemical Society; to establish a Perkin Research Fund, for the promotion of chemical research, to be administered through the Chemical Society. The committee organized in the United States has decided, for a number of reasons, to hold a separate American celebration in the late fall. The program laid out by the committee, as noted in our issue of June 14, comprises: a banquet and symposium on the coal-tar industry, to be held Oct. 6, to which Dr. Perkin is to be invited as guest of honor; the presentation to Dr. Perkin of a personal token; the foundation of a Perkin medal to be awarded annually to an American chemist for distinguished work in applied chemistry; and the establishment of the nucleus of a fund for founding a reference and circulating library at the Chemists' Club, New York City, which is to contain duplicate sets, one of them to be used for circulation among American chemists. The American committee states that Dr. Perkin's discovery of the dyestuff "Mauve" virtually transformed chemistry from an empirical art to a branch of applied science. Besides stimulating the study of chemistry, his discovery laid the foundation for the great coal-tar industry, the products of which cover so wide a range of usefulness. The Committee of Fifteen invites subscriptions for the Perkin Jubilee Fund. Prof. Chas. F Chandler, of Columbia University, is chairman, and Mr. Adolf Kuttroff, of the Continental Color & Chemical Co., 128 Duane St., New York City, is treasurer.

A TRANSATLANTIC STEAMER FOUNDERED off Hormigas Island, near Cape Palos, on the coast of Spain, on Saturday evening, Aug. 4. The vessel was the "Sirio," an iron steamship of 4,140 tons, with engines of 5,000 HP., and was built in 1883. It had about 500 to 600 passengers on board, mostly Italian immigrants. The vessel struck rocky shoals in a difficult passage out of the customary steamer course and settled rapidly; the boilers exploded while it was going down. Over two hundred persons were lost.

AN ELECTRIC RAILWAY COLLISION killed two persons on the Lake Shore Electric R. R. near Vermillion, O., on Aug 4. An eastbound car collided with a westbound car on a curve while both were running at high speed; the two cars telescoped each other. Most of the passengers of both cars were injured.

A REDUCTION IN PASSENGER FARES from 3½ and 3 cts. to a maximum of 2½ cts. has been announced by the Pennsylvania R. R., taking effect Aug. 1. After Sept. 1, moreover, 1,000-mile tickets will be sold for $20; these tickets are transferable and no cash deposit is required. Consequently, the fare is virtually reduced to 2 cts. per mile. It is expected that competing lines of the Pennsylvania system will meet this reduction.

THE NEW JAPANESE CABLE, affording direct communication via Bonin between Japan and the United States, has been opened to the public.

THE FEDERAL SAFETY APPLIANCE ACTS have been violated by many Western railroads, according to Attorney-General Moody. He has directed that a number of them be prosecuted for the recovery of the statutory penalty. Among these are the Chicago, Burlington & Quincy R. R. Co., for 17 penalties, and the St. Louis, Iron Mountain & Southern Ry. Co., for 13 penalties.

A RAPID TRANSIT SUBWAY SYSTEM for Cambridge, Mass., was authorized by the last session of the Massachusetts Legislature, and the provisions of the act, or a portion of them, have been accepted by the Boston Elevated Ry. Co. Under the terms of the act the company named is to build a subway from a point a little beyond Harvard Square through Massachusetts Ave. and Main St. to or near the new West Boston Bridge across the Charles River. The subway is to be for the use of either trains or surface cars. Connection with Boston will be made by an elevated structure over the bridge named, and thence either by a subway or elevated road to Scollay Square or to the present subway in Park St. The Boston portion will be built by the Transit Commission of that city. Another main line from near Harvard Square to the Charles River, and a branch from that line and another branch from the line first described are authorized for future construction by the terms of the act. The city of Cambridge is given the option of purchasing the subways from the company after 20 years from the date of opening the Main St. subway, or earlier by mutual agreement. The terms of purchase are summarized in the Boston "Globe" for July 13 (which also contains a map of the proposed system) as follows:

> The purchase price must be a reimbursement to the company of the original cost of the subway or subways, together with the cost of all additions and alterations, with simple interest at 7% on the actual cost to the stockholders, to be computed from the time of the payment by the stockholders up to the time of the purchase, with an addition of 3½% to be paid on all sums expended for construction up to the time of the opening of the subways, less the amount which has been paid in dividends to stockholders holding shares issued for subway construction; and also less the amount the company may have received from the sale of land, buildings or material.

A BROKEN AXLE ON A CAR of a Brooklyn Bridge elevated train caused on Aug. 3 one of the worst congestions experienced on the bridge in many years. About 8 a. m. the axle snapped on the front wheels of the first car of a five-car train. The cars left the track, but the motorman applied the emergency brake and stopped the train in time to prevent a more serious accident. Four following trains, all crowded with passengers on their way to Manhattan, were likewise stalled. These descended from the cars, at some risk, to the roadway below, and, along with thousands of others whom the trolley cars could not accommodate, had to walk across the bridge. Traffic on the elevated was not resumed until nearly noon.

THE USE OF ALCOHOL in the arts and industries will, according to a recent act of Congress, be free of tax after Jan. 1, 1907. Regulations for denaturing are now being prepared by the Treasury Department, and investi-

gations are being made in regard to the processes of denaturing in foreign countries. Prof. Chas. E. Lucke, Assoc. M. Am. Soc. M. E., of Columbia University, is to investigate for the Department of Agriculture the possibilities of alcohol as fuel, since large quantities, it is expected, will be used for small power engines. Patented vaporizers, carburettors or engines may be sent to Prof. Lucke by any persons who desire to have them tested; no charge will be made to the owners except that for transportation. Meanwhile, a number of reports on the subject of denatured alcohol has already been received from U. S. consular officers in Italy, France and Germany, and these have been published in the Daily Consular and Trade Reports of Aug. 6, issued by the Bureau of Manufactures, Department of Commerce and Labor.

THE IMPROVEMENT OF NEW YORK HARBOR by the construction of Ambrose Channel has been greatly furthered by the enactment of the omnibus lighthouse bill at the recent session of Congress. By the terms of the river and harbor act of 1899 a project was adopted for making an entrance to New York harbor by way of Ambrose Channel (formerly known as East Channel), to be 2,000 ft. wide and 40 ft. deep at mean low water. The work was authorized to be done under a continuing contract at a cost not exceeding $4,000,000; it involves the excavation of a channel some seven miles in length. In June, 1905, the work, which is under the control of the Corps of Engineers, U. S. A., was reported as about one-third completed. Meanwhile the Lighthouse Board has been authorized to place lighthouse and light buoys on the channel as fast as the work progresses. The plans for illumination are so extensive that the channel is already popularly known among sailing-masters as "Ambrose Boulevard." The appropriations by the last Congress under the omnibus lighthouse bill were as follows: For the construction of a light vessel for the sea entrance to the harbor, $50,000, with authorization to enter into a contract not to exceed $115,000; for a lighthouse on Staten Island, and for raising West Bank light, $50,000, a contract not to exceed $100,000 being authorized; for moving North Hook beacon light, $6,000; for a tank light vessel, $15,000; for a stone beacon at Craven Shoal, $20,000; for 13 gas buoys in Ambrose Channel and 11 gas buoys in Gedney and Main Ship Channels, $43,000. Other appropriations will be made when required; the illumination of the channel, it is expected, will be completed at the same time as its construction.

THE CHESAPEAKE AND DELAWARE CANAL, connecting the waters of the Chesapeake and Delaware bays, may be purchased by the national government and developed into an open waterway of depth and capacity sufficient to accommodate at mean low water the largest vessel afloat. The last session of Congress authorized the President to appoint a commission to examine and appraise the value of the works and franchise of the present canal company with a view to purchasing them; also to investigate the feasibility for the purpose of such a waterway, of the so-called Sassafras route. The commission was to consist, in the words of the resolution, "of an officer or retired officer of the Engineer Corps of the U. S. Army, an officer of the U. S. Navy, and one person from civil life"; the President appointed Major Clement A. Flagler, Lieut. Frank Taylor Chambers, M. Am. Soc. C. E., and Gen. Felix Agnus, of Baltimore, Chairman. A meeting of the committee for the purpose of organization was held July 30.

THE U. S. RECLAMATION SERVICE, which has now been in existence for four years, has 22 projects under construction and has already supplied water to 13,600 acres of land. Completed construction to July 1, 1906, included 241 miles of main canal and 504 miles of distributing canals and ditches. Tunnels aggregating some 5½ miles in length have been driven, and 233 miles of wagon road, largely in solid rock, have been constructed. Some 300 office and other buildings have been erected, and about 520 miles of telephone lines have been installed and are now in operation. The government cement plant at Roosevelt, Ariz. (Eng. News, Aug. 24, 1905), has turned out 43,000 bbls. of cement. A total of 2,889,000 ft. B. M. of lumber has been sawed at government mills, the timber for which was cut from government reserves. The Reclamation Service has increased in numbers, during the four years of its existence, from a dozen to more than 400 engineers and assistants. Contracts now under way involve an expenditure of over $25,000,000. The contractors are now employing about 10,000 men, and the Reclamation Service has more than 2,000 men engaged on work which it is doing without the intervention of contractors. The monthly expenditure of the service is now about $1,000,000. It is expected that this will diminish rather than increase in the future.

A SEWAGE EXPERIMENT STATION under the direction of the New York State Department of Health is to be established at the Saratoga Springs sewage disposal works. Money to this end was provided in the way of a small appropriation made by the last Legislature. It is expected that the station will be ready for operation soon. Among other studies, it is proposed to make experiments with the treatment of creamery and factory wastes. Dr. Eugene H. Porter is Commissioner of Health and Mr. A. H. Seymour is Secretary of the Department, the offices of which are at Albany, N. Y.

THE PRODUCTION OF SLATE in the United States, according to a bulletin issued by the U. S. Geological Survey, was greater in 1903 than for any other year between 1901 and 1905. Up to 1903 the production increased because the building trades were active and because large quantities were shipped to Great Britain, where a protracted strike in the Welsh quarries had reduced the available supply. Since 1903 the production has decreased; the causes assigned are labor troubles in the building trades; the partial settlement of the strikes in Wales and the competition in English markets of French roofing slates of small sizes. The exports for the years from 1903 to 1905 were, respectively, $838,683, $449,743, and $408,309. Very little slate is imported into this country. The average price of slate per square for the years from 1900 to 1905 has been, respectively, $3.01, $3.45, $3.88, $3.78 and $3.69.

PERSONALS.

Mr. B. R. Craig, City Engineer of Kingston, Ont., has resigned to become Resident Engineer of the Grand Trunk Pacific Ry. west of Fort William.

Mr. Guy D. Swingley has been appointed Division Engineer of the Connellsville Division of the Baltimore & Ohio R. R. to succeed Mr. John Ware, resigned.

Mr. E. D. Crowley, of the Engineering Department of the Western Pacific Ry., has resigned his position to become Chief Engineer of the Healey-Tibbitts Construction Co., of San Francisco, Cal.

Dr. Cressy L. Wilbur, Chief of the Vital Statistics Division of the Department of State has been appointed Chief Statistician of the Mortality Statistics of the United States Census Office at Washington, D. C.

Mr. W. J. Patterson, President of the Heyl & Patterson Co., of Pittsburg, Pa., manufacturers of conveying and elevating machinery, was married Aug. 1, 1906, to Miss Fay Templeton, the actress, at Ridley Park, Pa.

Mr. O. H. Crittendon, Resident Engineer of the International & Great Northern R. R., has been promoted to Superintendent of Bridges, Buildings and Water Service, to succeed A. L. Bowers, resigned. His headquarters are at Palestine, Tex.

Mr. Mortimer E. Cooley, M. Am. Soc. M. E., Head of the Mechanical Department of the University of Michigan, has been retained by the Omaha (Neb.) Water Board as Appraiser to act in conjunction with two other appraisers to determine the value of the Omaha Water Co.'s plant.

Mr. W. E. Maxson, Superintendent of the Beaumont Division of the Gulf, Colorado & Santa Fe Ry., has been promoted to General Superintendent, to succeed Mr. F. G. Pettibone, who has been made Vice-President and General Manager. Their headquarters are at Galveston, Tex.

Mr. F. C. Irvine, formerly Assistant Engineer of the Cleveland & Marietta Ry., a subsidiary line of the Pennsylvania R. R., has been appointed Right-of-Way Engineer in the Real Estate Department of the Pennsylvania lines. This is a new office which has just been created, while the office of assistant engineer of the Cleveland & Marietta Ry. has been abolished.

Prof. Mansfield Merriman, M. Am. Soc. C. E., Professor of Civil Engineering at Lehigh University, has been granted a one-year leave of absence, which he will spend in practice as a consulting engineer. He, with Mr. Clarence W. Hudson, M. Am. Soc. C. E., who has resigned his position as Assistant Engineer of the Phoenix Bridge Co., will open offices at 45 Broadway, New York City, Sept. 1, as Consulting Engineers. They will give special attention to investigations and reports on water supply and water power, the design, inspection and erection of bridges, foundations, steel buildings, etc.

Obituary.

William Weber, a Government Contractor, committed suicide at Huntington, W. Va., Aug. 2, by taking opium.

Harry E. Parker, Superintendent of Manufacture of the Amoskeag Manufacturing Co., dropped dead at his home in Manchester, N. H., Aug. 1.

Samuel L. Clapp died at his home in Brooklyn, N. Y., Aug. 1. He was born at Leicester, Mass., in 1826. He superintended the construction of the dredges used for the De Lesseps Panama Canal.

Walter F. Smock, a civil engineer employed by the Southern Pacific Co. on the construction of a new bridge near Springfield, Ore., was drowned July 8 while in bathing. He was 26 years of age and a graduate of the University of Illinois.

Robert William Smith, of Philadelphia, Pa., a former Treasurer of the Pennsylvania Railroad, died at Spring Lake, N. J., Aug. 1, aged 70 years. He had been in the employ of the company since 1885, but was placed on the retired list two years ago.

Samuel L. Southard, who had charge of the construction of the first railroad that was built across the Andes Mountains, died at Chicago, Ill., July 30. He was born in New York City in 1836, and was a grandson of Samuel L. Southard, Secretary of Navy, 1823 to 1825.

Daniel B. Wesson, member of the well-known firm of Smith & Wesson, died at his home, in Springfield, Mass., Aug. 4, after an illness of four years. Mr. Wesson was the inventor of several improvements in firearms, the most important being the automatic cartridge shell extractor and self-lubricating cartridge.

Albert W. Fiero, M. West. Soc. E., a member of the firm of R. W. Hunt & Co., of Chicago, inspecting engineers, died at Battle Creek, Mich., July 28. He was born in that city in 1849, and was at one time engineer of the Peninsular Ry. (now a part of the Michigan Central Ry.), and was afterwards connected with the Joliet Steel Co. In 1888 he became associated with the firm above mentioned as one of its original members.

A. H. Thompson, the well-known Geographer of the United States Geological Survey, died at his home in Washington, D. C., July 31. He was born at Stoddard, N. H., Sept. 24, 1839, and was educated at Southboro, Mass., and Wheaton, Ill., taking a scientific course. He fought on the Union side during the Civil War, being First Lieutenant of 139th Illinois Volunteer Infantry. In 1869 he became Curator of the Illinois Natural History Society, and in 1870 he was appointed Topographic Engineer of the Geological Survey, which position he had since held. During the exploration of the Colorado River, 1870 to 1878, under Major Powell, he had charge of the geographic work. From 1884 to 1895 he was in charge of the work of the Geological Survey west of the Mississippi River. The exhibits of the Survey at the Louisiana Purchase Exposition were also under his charge.

ENGINEERING SOCIETIES.

COMING MEETINGS.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Aug. 15 to 17. Annual convention at New Haven, Conn. Secy., Frank P. Foster, Corning, N. Y.

THE NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 12-14. Annual Convention at Fabyan House, White Mountains, N. H. Secy., Willard Kent, Narragansett Pier, R. I.

AMERICAN PUBLIC WORKS ASSOCIATION.
Sept. 14-15. Second Annual Meeting at Atlanta, Ga. Secy., W. H. Flint, Chattanooga, Tenn.

LEAGUE OF AMERICAN MUNICIPALITIES.
Sept. 26 to 28. Annual convention at Chicago, Ill. Secy., Jno. MacVicar, Des Moines, Ia.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 2 to 5. Annual Meeting at Birmingham, Ala. Secy., G. W. Tillson, Municipal Bldg., Brooklyn, N. Y.

AMERICAN STREET AND INTERURBAN RAILWAY ASSOCIATION.
Oct. 15 to 19. Annual Convention at Columbus, O. Secy., Bernard V. Swenson, 60 Wall St., New York City.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.—The regular quarterly meeting of the association will be held at the Auditorium Hotel, Chicago, Ill., Sept. 11-12. The Tuesday morning session will be devoted to business, while the meeting on Wednesday will be given over to the reading of papers, among which will be: "The Behavior of Structural Materials Under Earthquake Shock and Fire at San Francisco," Mr. Richard L. Humphries; "Work of the German Association of Portland Cement Manufacture," Mr. S. B. Newberry.

AMERICAN GAS INSTITUTE.—The representatives of the American Gas Light Association, the Western Gas Association and the Ohio Gas Light Association met at the Auditorium Hotel, Chicago, Ill., July 10, and organized the American Gas Institute by merging the three above associations into one. The resolution adopted is as follows:

Resolved, That by virtue of the powers conferred upon us by our respective associations, namely, the American Gas Light Association, the Western Gas Association and the Ohio Gas Light Association, we, the representatives thereof, here present, declare that these three associations do now merge into and form the American Gas Institute, the officers of the three participating associations retaining their respective offices until the merger shall become effective, all present salaries to terminate at the time of the first meeting of the institute.

The joint committee decided to hold the first meeting of the Institute at Chicago, Oct. 17 to 19, when permanent officers will be elected and suitable papers presented. Temporary officers were selected as follows: President, Mr. James W. Dunbar; Vice-President, Mr. Geo. C. Ramsdell; Secretary and Treasurer, Mr. McIlhenney. Temporary committees on papers, entertainment, badge and finance were also appointed.